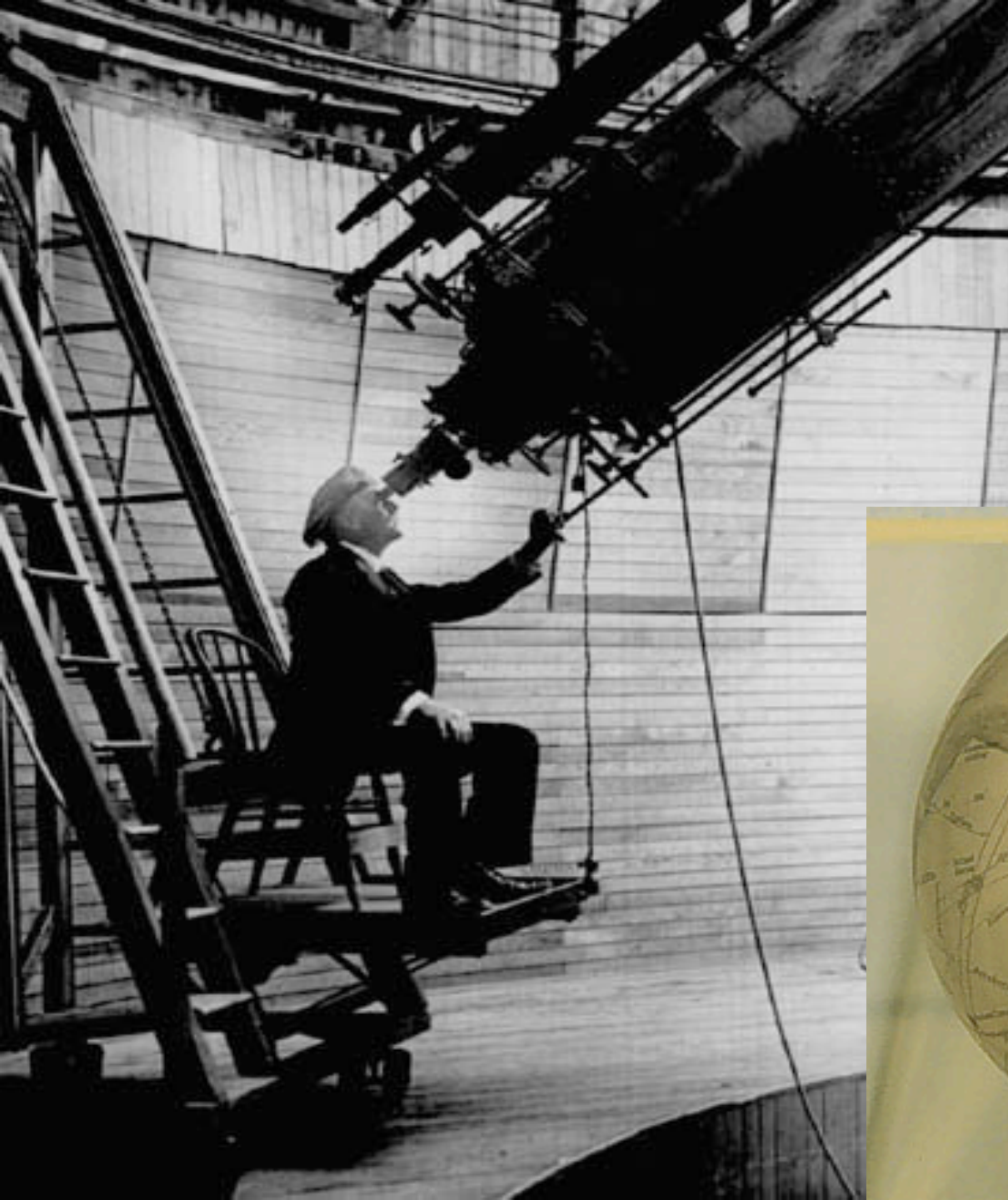


Mars' Mysteries

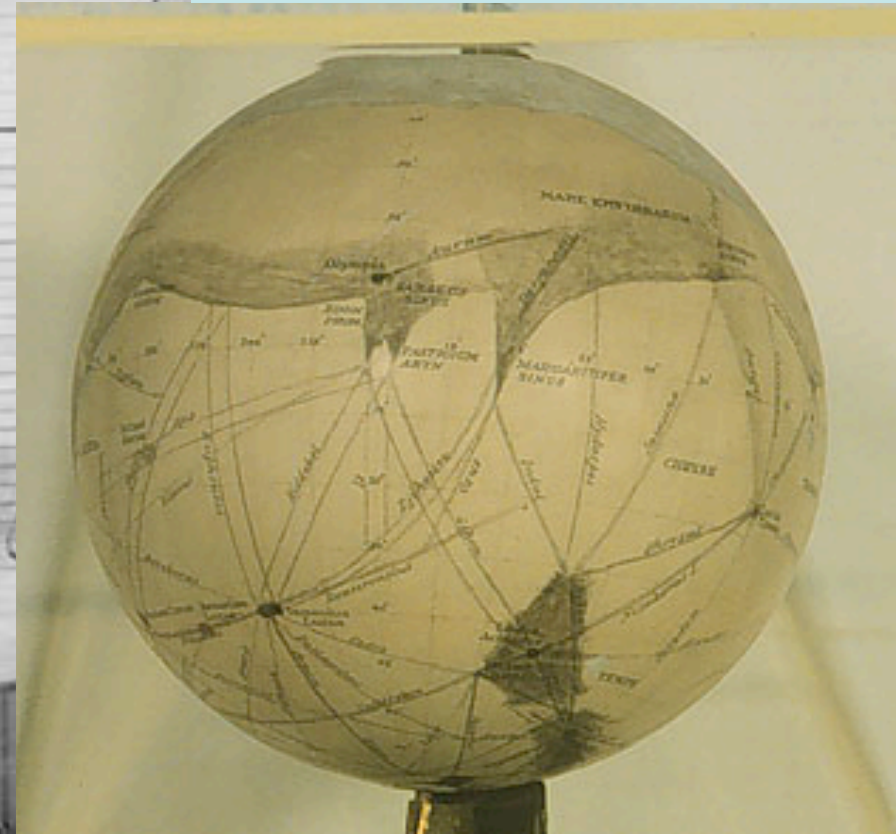
*Donna M. Jurdy
Earth & Planetary Sciences
Northwestern University*



PERCIVAL LOWELL AT THE
24 INCH REFRACTOR,
FLAGSTAFF, ARIZONA
OBSERVING MARS DURING
FAVORABLE OPPOSITION
(PERIHELIC OPPOSITION)

OF 1894

BELOW IS A GLOBE
CONSTRUCTED FROM HIS
DRAWINGS



H.G. Wells
*The War of
the Worlds*
(1898)

The WAR of the WORLDS

By H. G. Wells

Author of "Under the Knife," "The Time Machine," etc.



Photograph
Of Mars
Taken with
A 5 Inch
Refracting
Telescope
June 2003,
2 Months
Before
Opposition



Mars • Global Dust Storm



June 26, 2001



September 4, 2001

Hubble Space Telescope • WFPC2

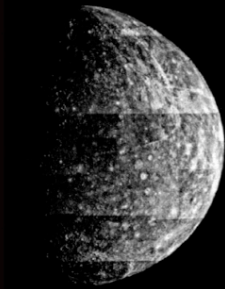
NASA, J. Bell (Cornell), M. Wolff (SSI), and the Hubble Heritage Team (STScI/AURA) • STScI-PRC01-31



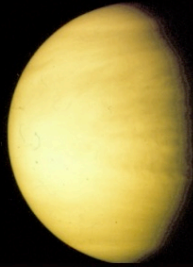
When is a face not a face?



Mercury



Venus



Earth



Moon



Mars



Radius (km)

2439

6052

6378

1738

3398

Mass (kg)

 3.30×10^{23} 4.87×10^{24} 5.98×10^{24} 7.35×10^{22} 6.42×10^{23} Density (kg/m³)

5420

5250

5520

3340

3940

Distance from
the Sun (A.U)

0.387

0.723

1.000

1.524

Mean Surface
Pressure (bars)

92

1

0.006

Mean Surface
Temp (K)

452

726

281

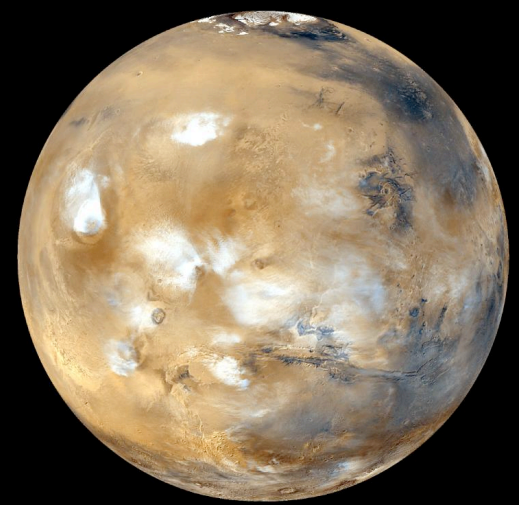
250

230

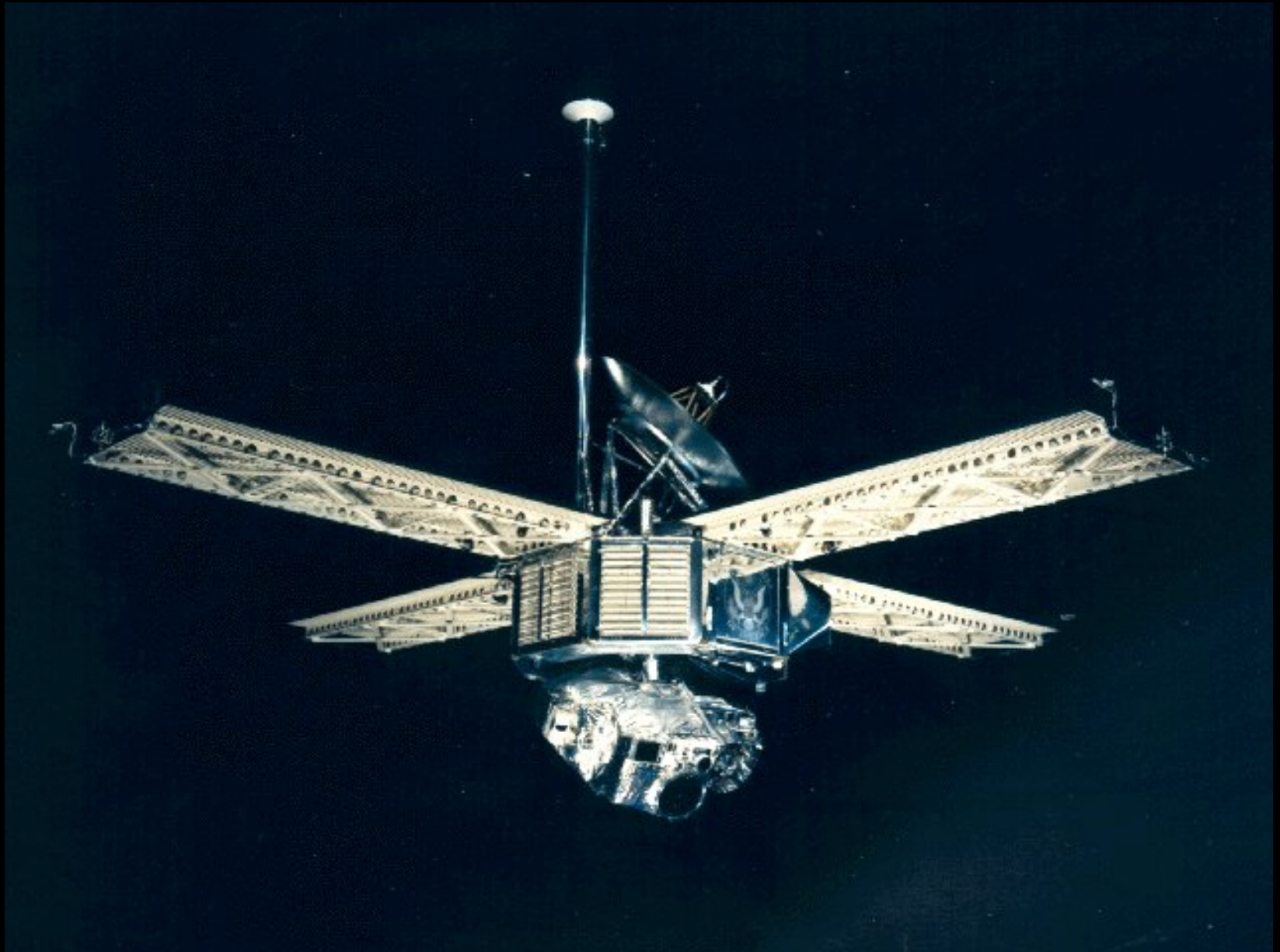
Atmosphere

CO₂N₂, O₂

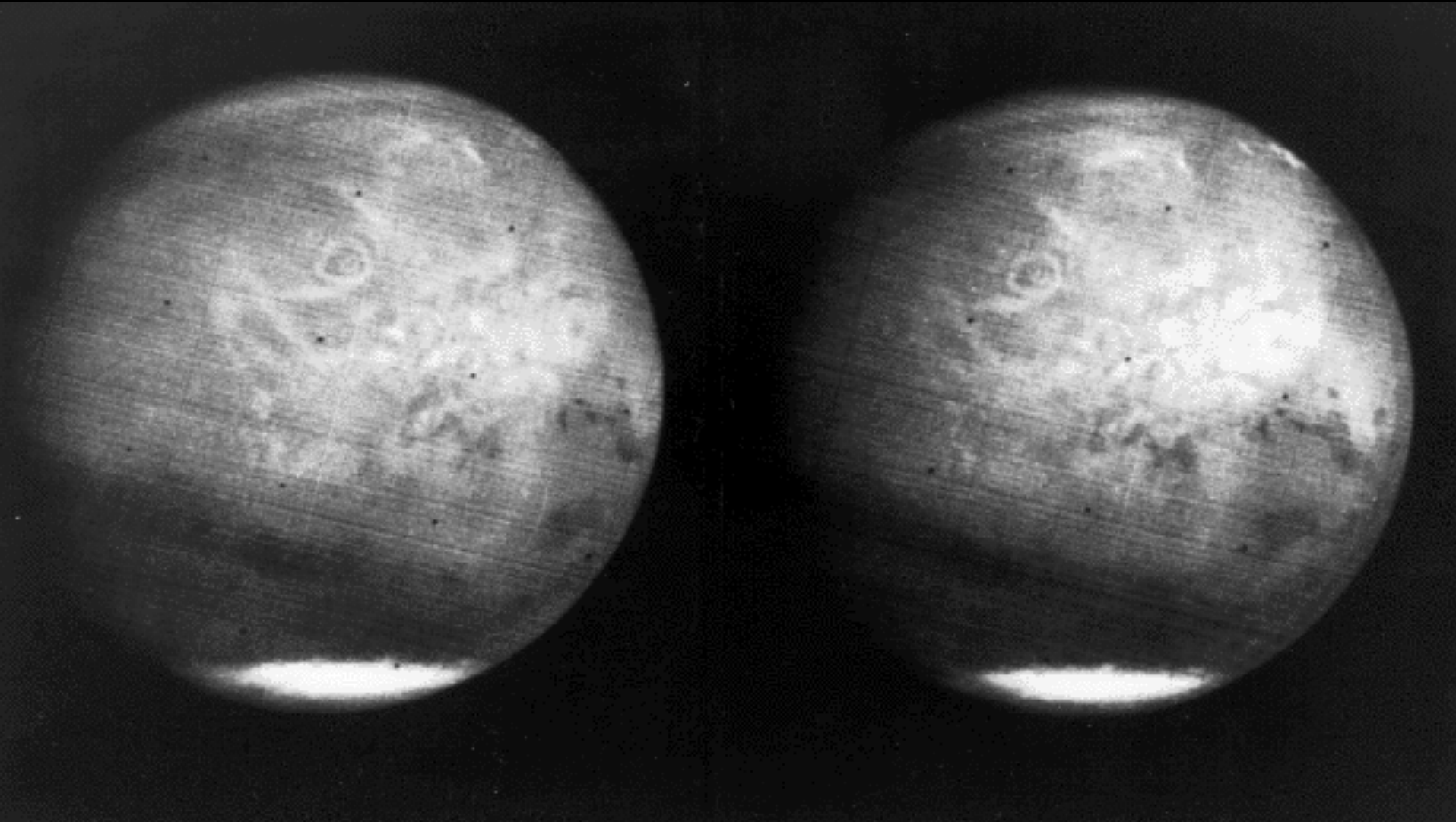
CO₂



Mariner 7 (1969)



Mariner 7 Approach to Mars



Olympus Mons, as seen from Mariner 9 (1971)



Olympus Mons Caldera

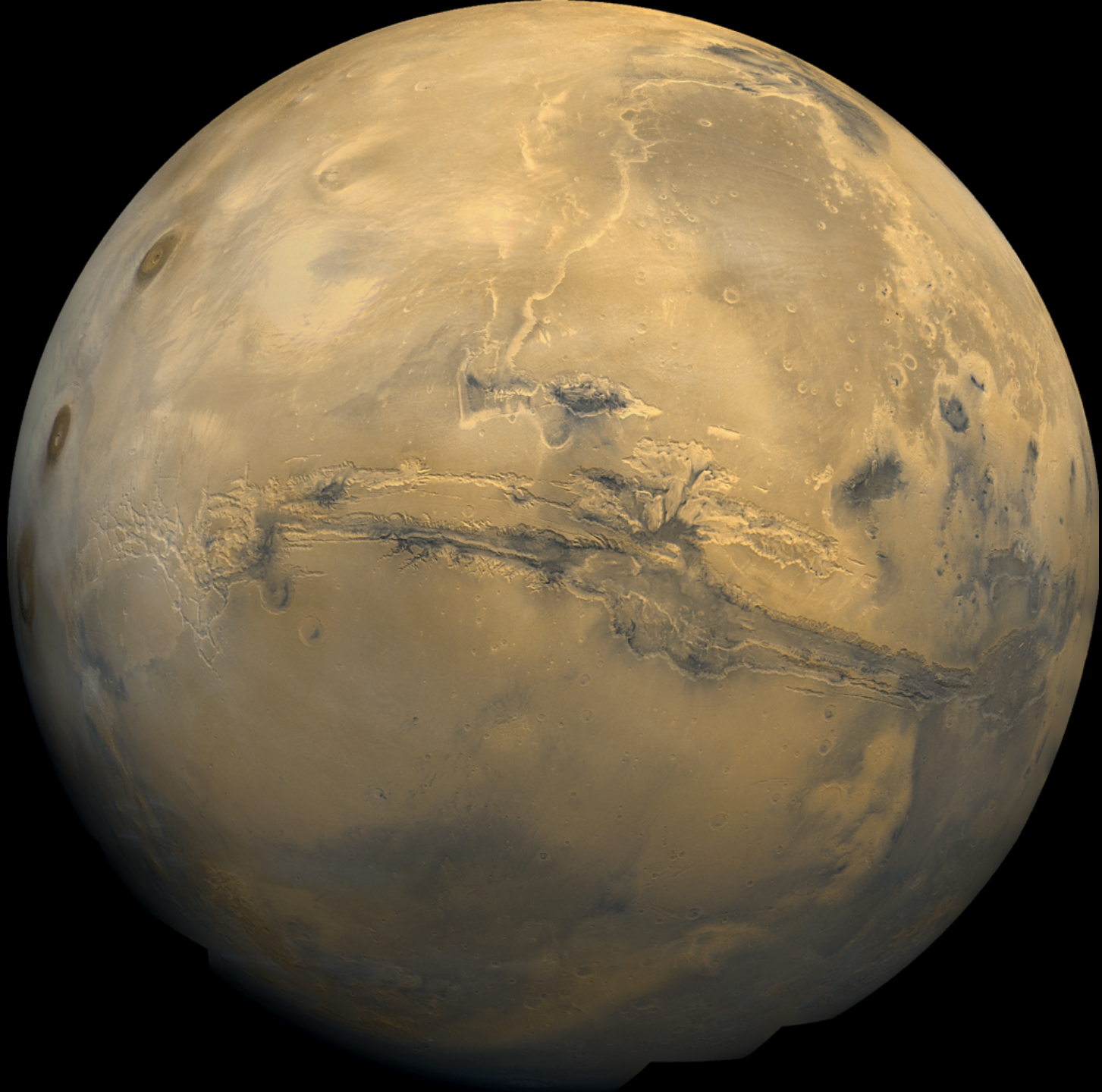


Viking 2 Liftoff, Sept 5, 1975

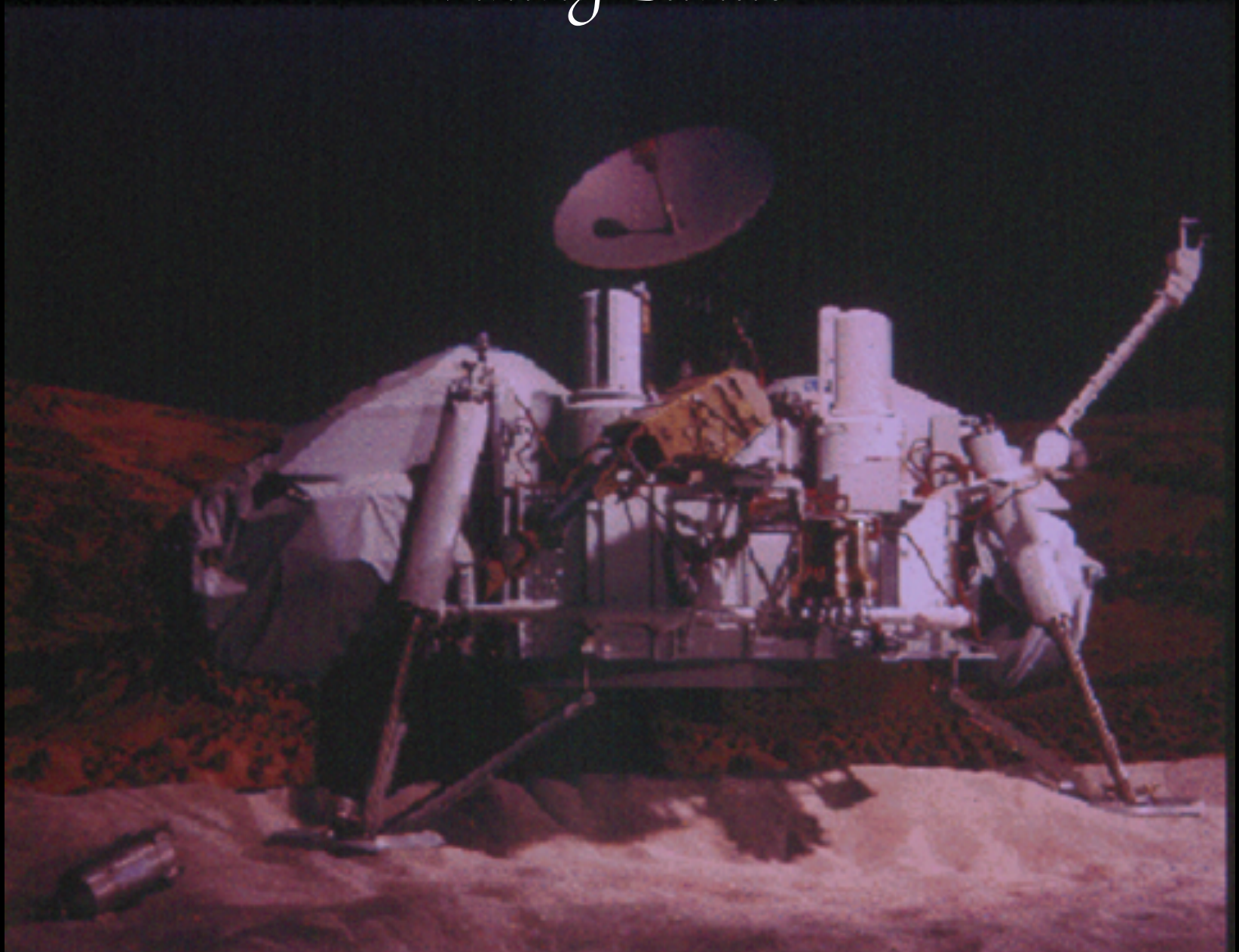


COMPOSITE
IMAGE OF
MARS
TAKEN
FROM
SMALL
TELESCOPES
ONBOARD
THE
2 VIKING
ORBITERS

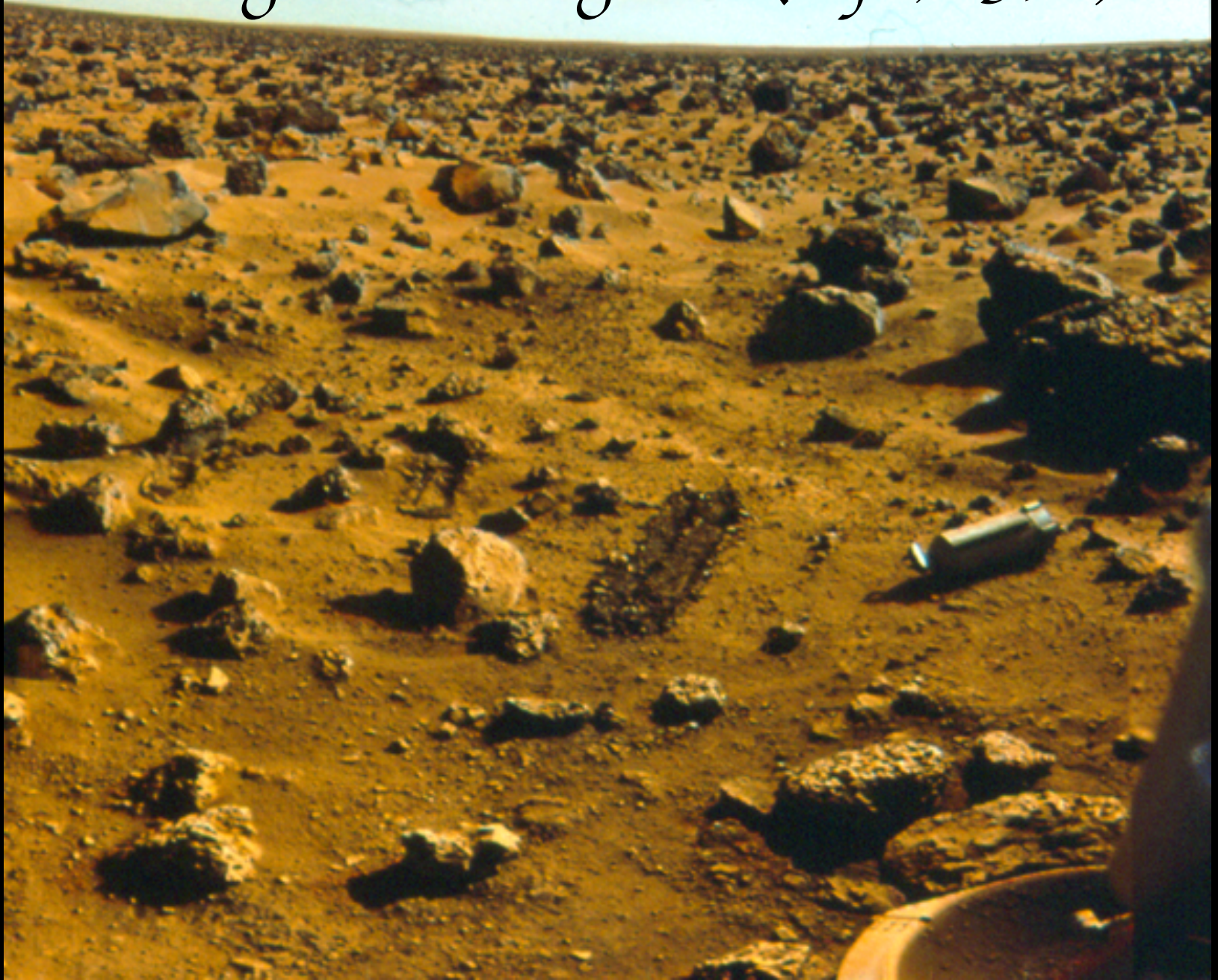
Mid
1970'S



Viking Lander



Viking 2 Landing Site (Sept, 1976)



Evidence for (really old, really tiny) Martians?



Mars Schematic

Oceanus Borealis

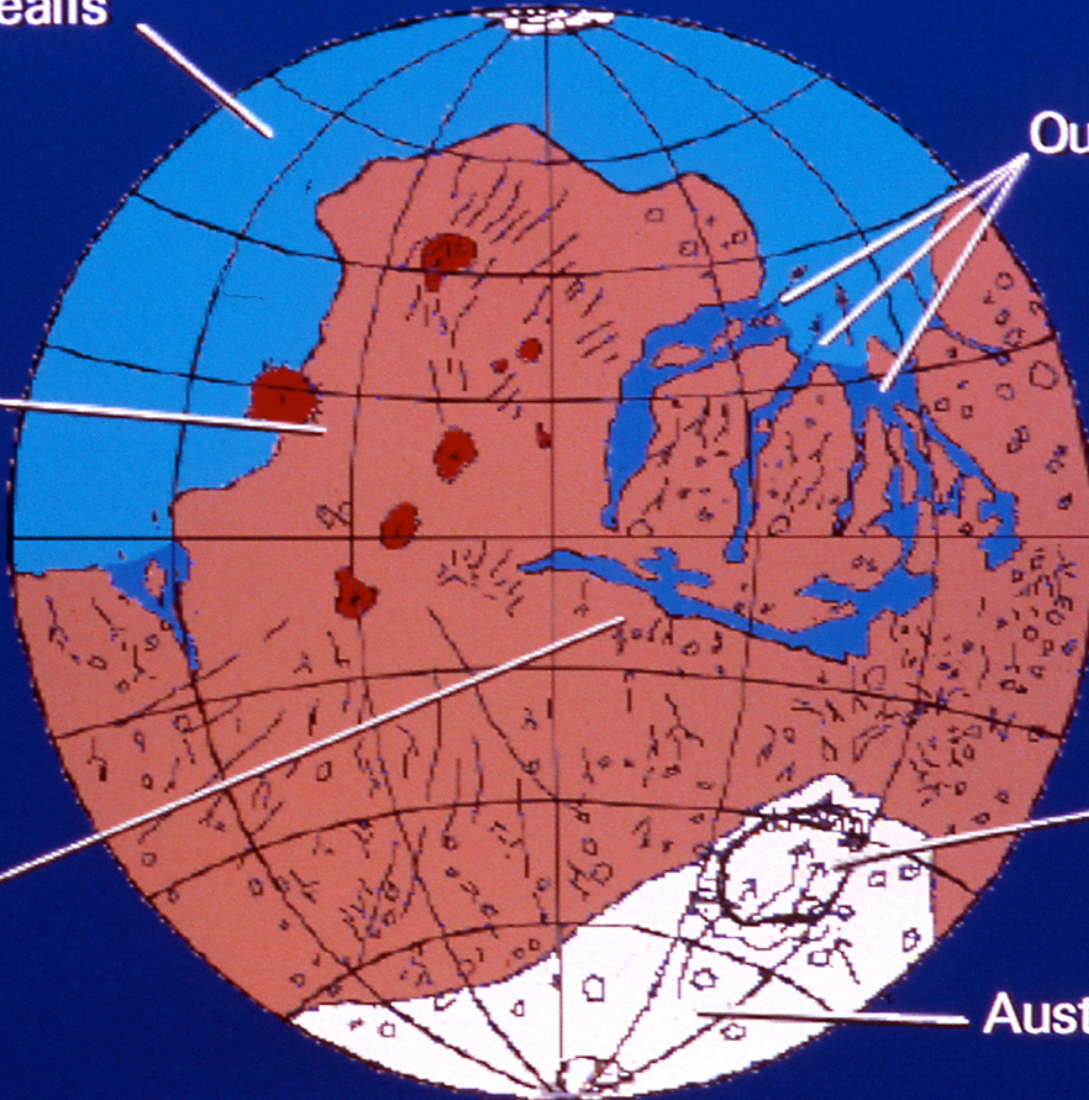
Outflow Channels

Tharsis
Volcanic
Province

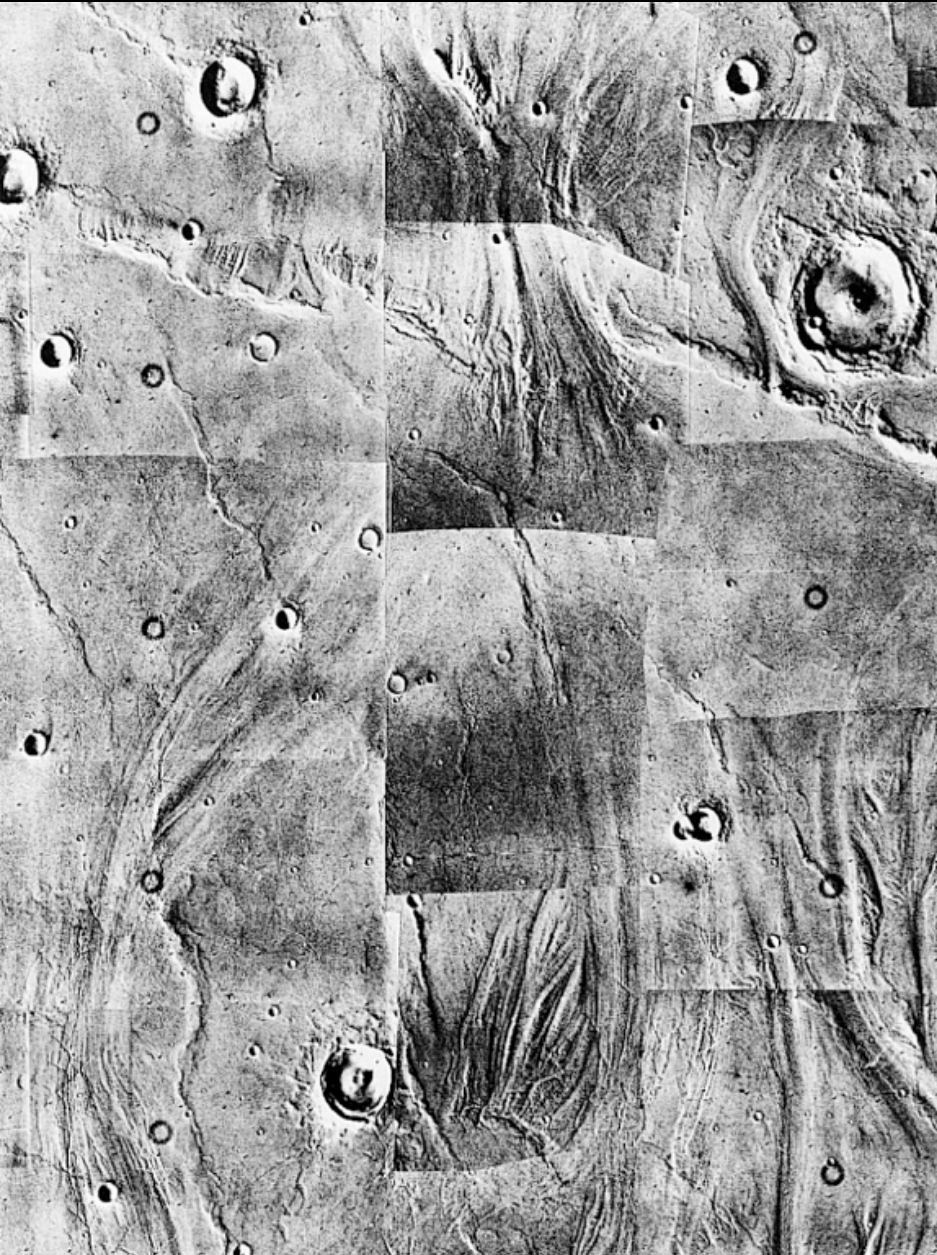
Argyre Basin

Valles
Marineris

Austral Ice Sheet



Water on Mars



❖ Ancient Mars had flowing water on its surface.

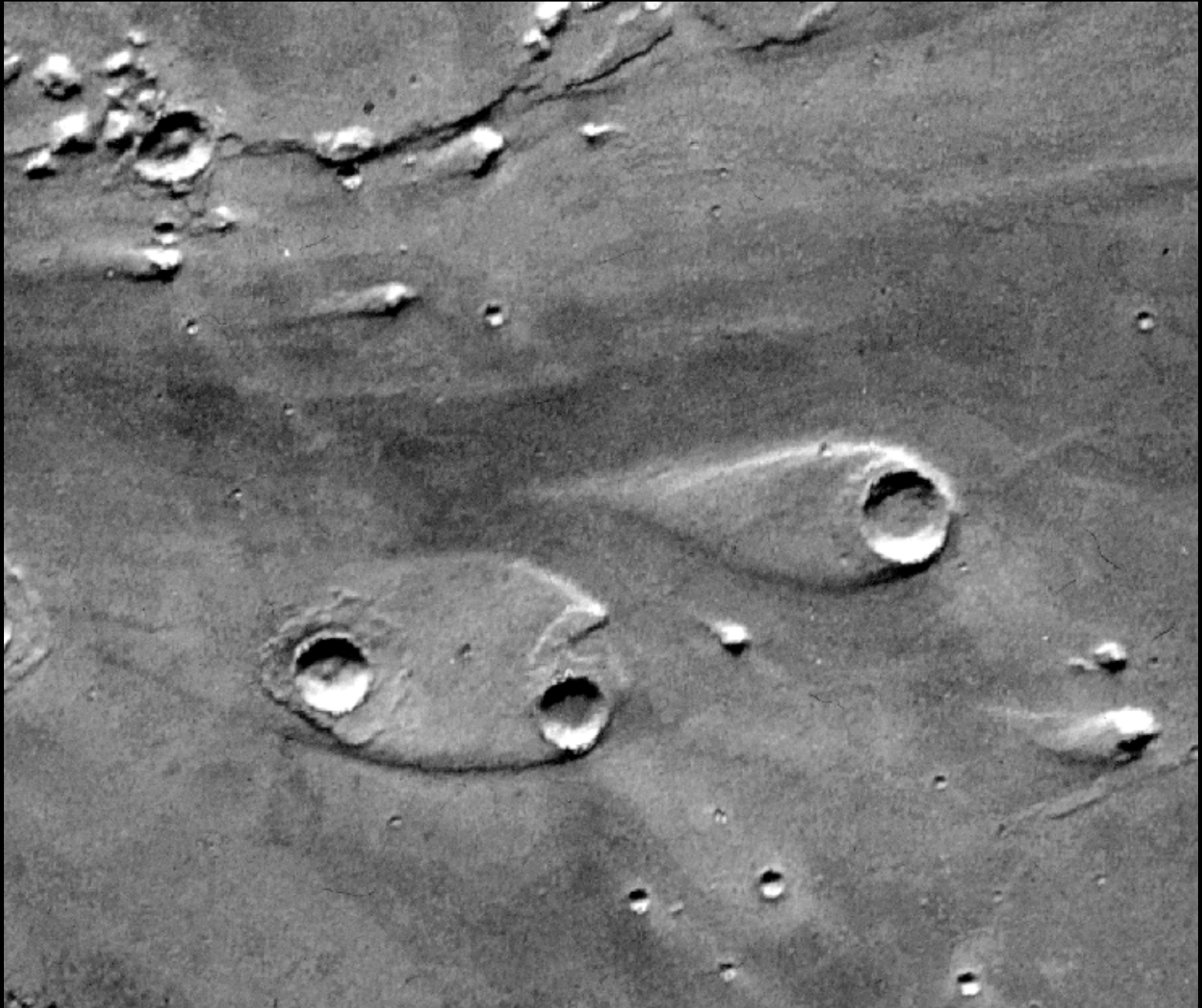
❖ These images clearly show the results of what appears to have been flowing water.

❖ The Viking landers actually recorded frost forming, then evaporating.

❖ There does not seem to be any liquid water on Mars today.

❖ It is possible that there may be surface water in shallow lakes under ice.

Channel Islands



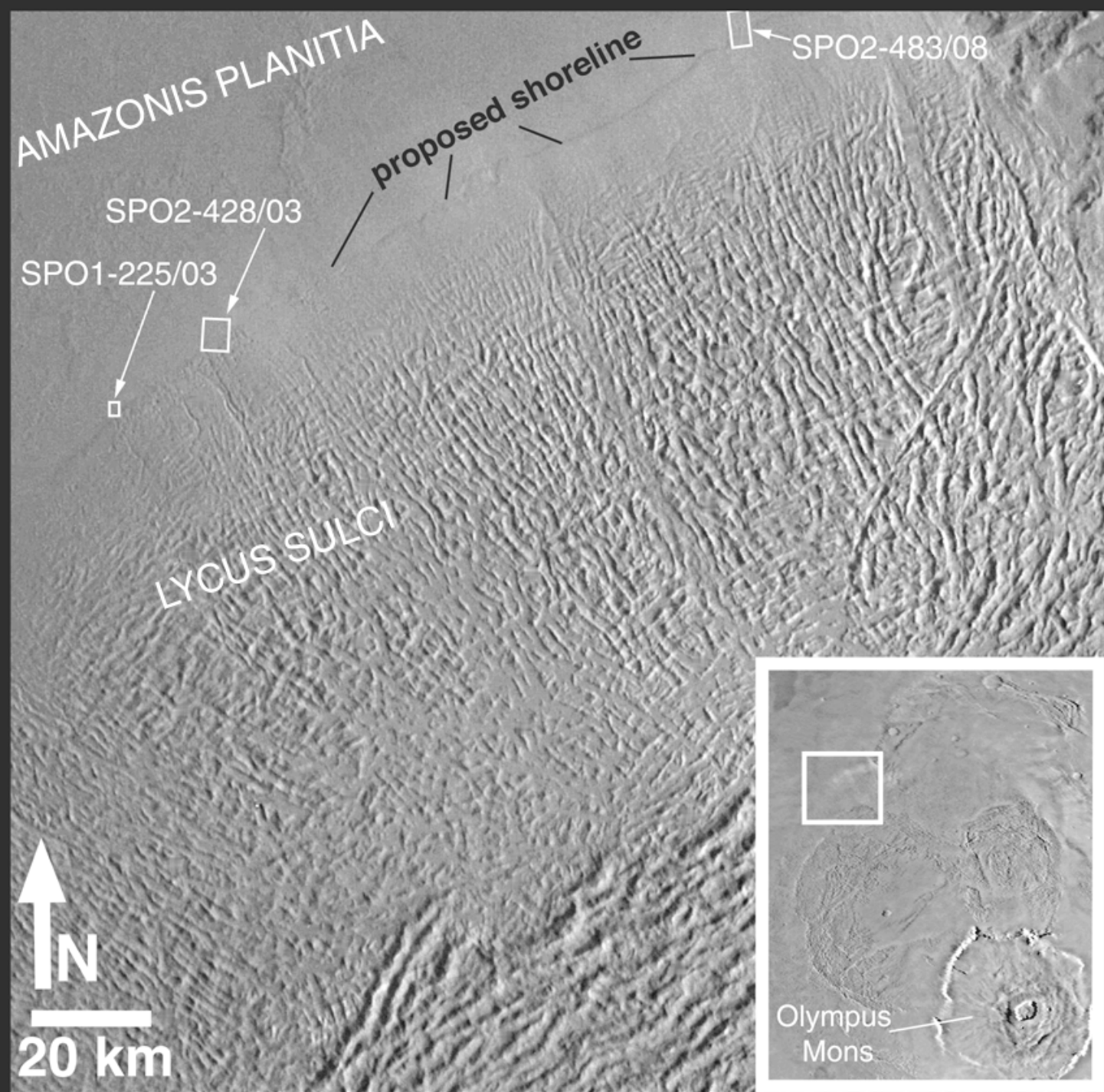
Erosion, Lobate Ejecta



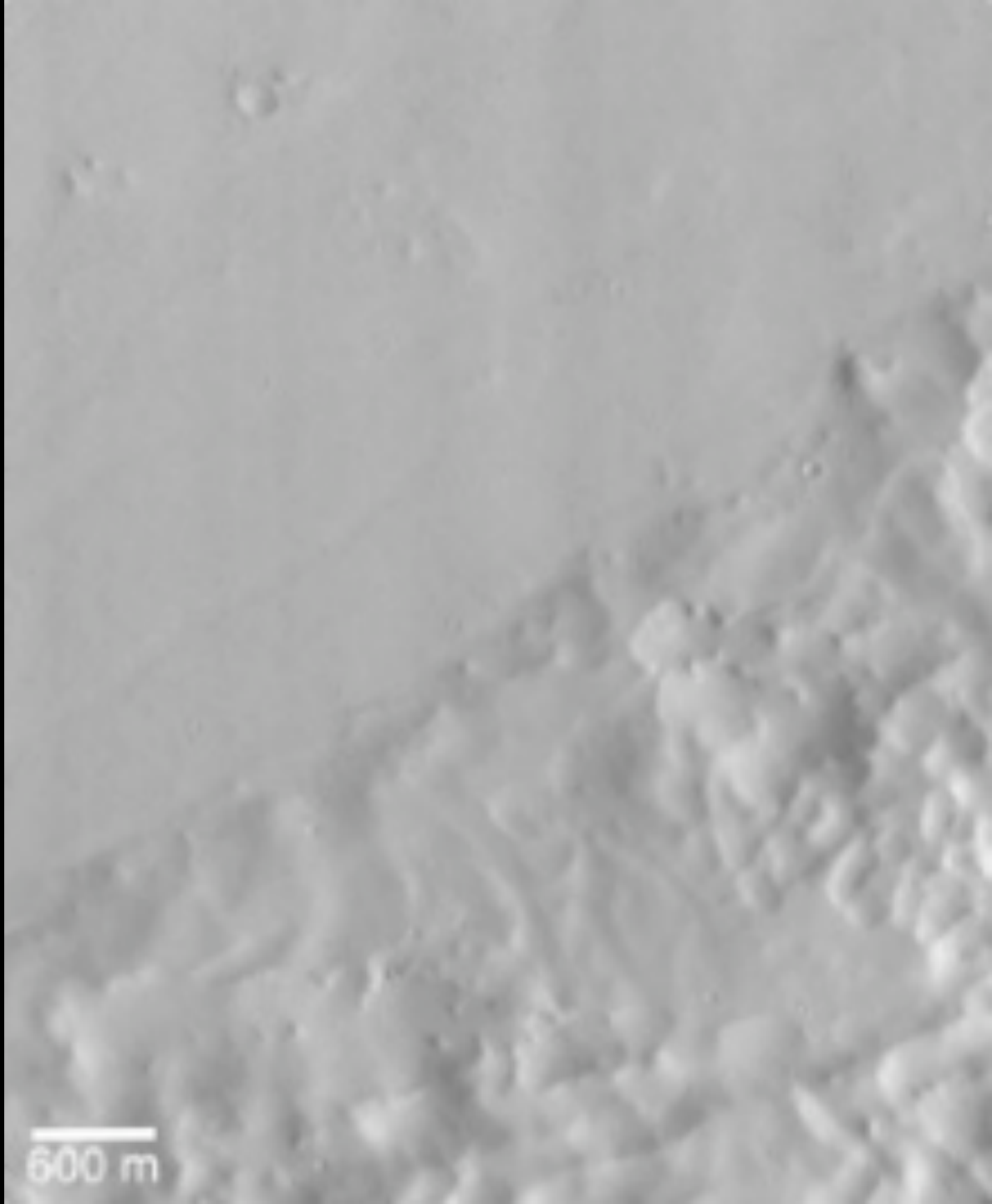
River Channels



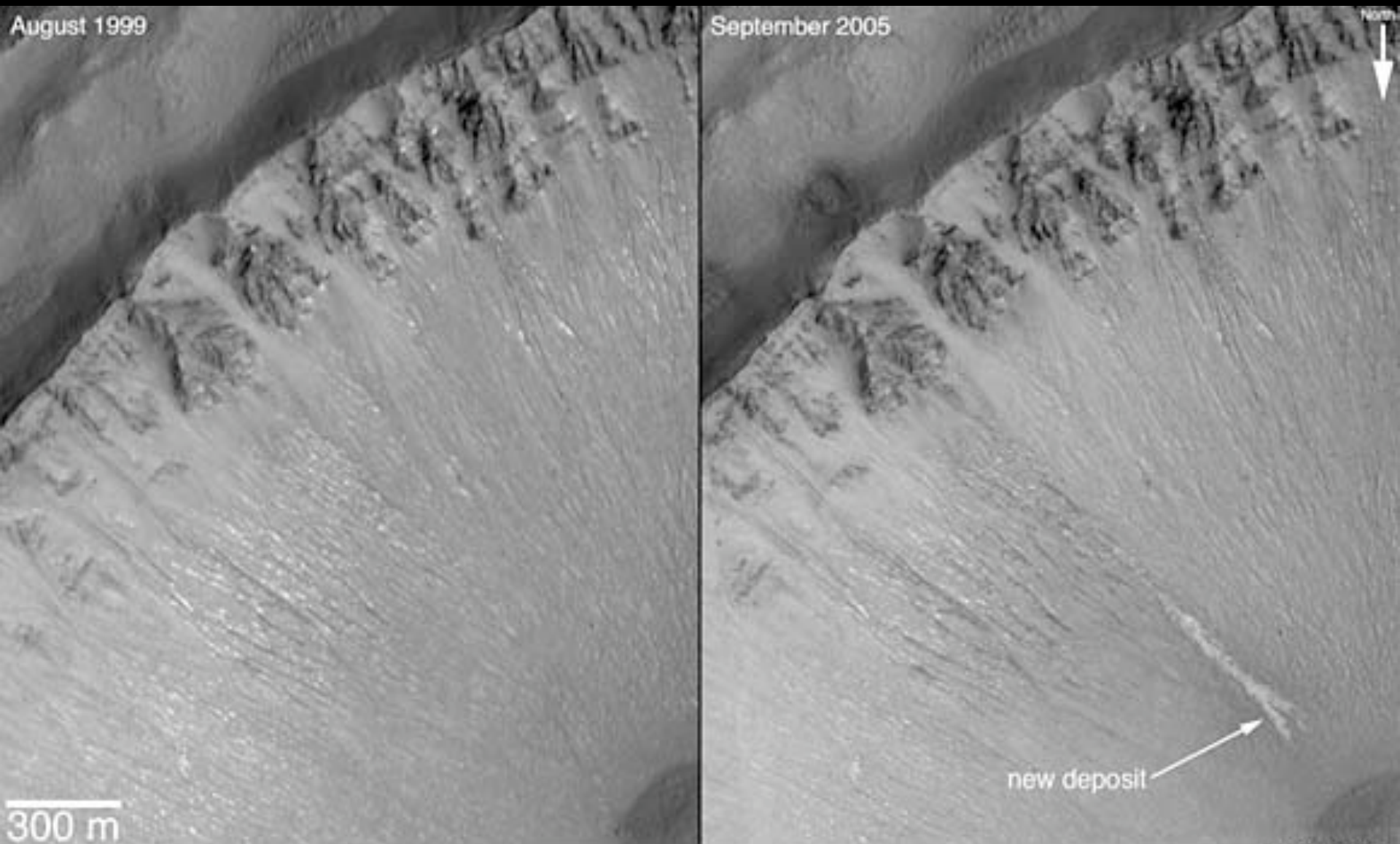
Ancient Martian Shoreline?



Shoreline? –
Up Close
and Personal



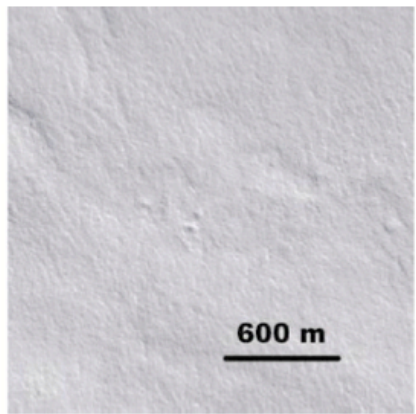
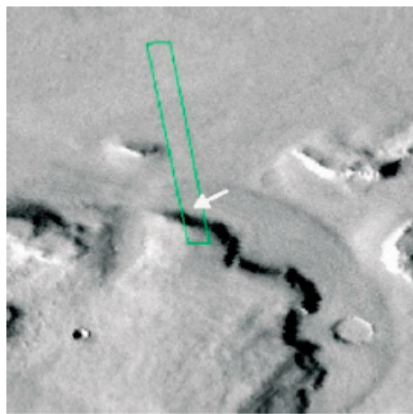
New Groundwater Flow?



MOC wide angle

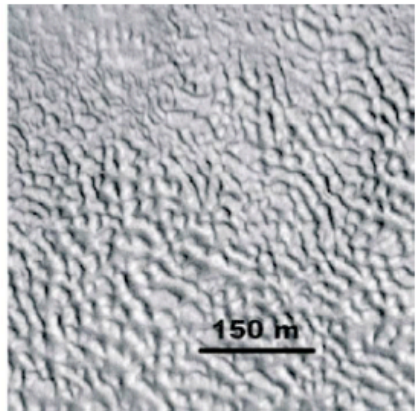
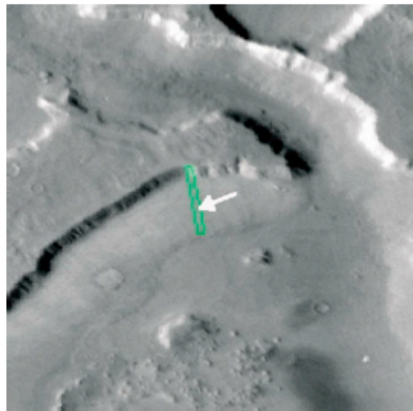
MOC narrow angle

Debris Aprons



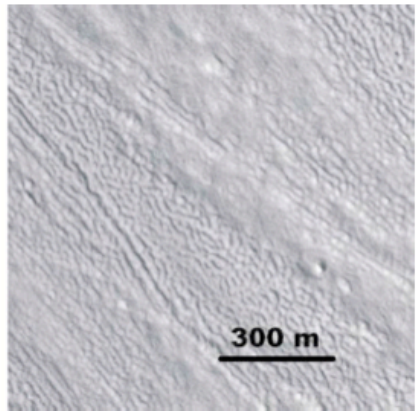
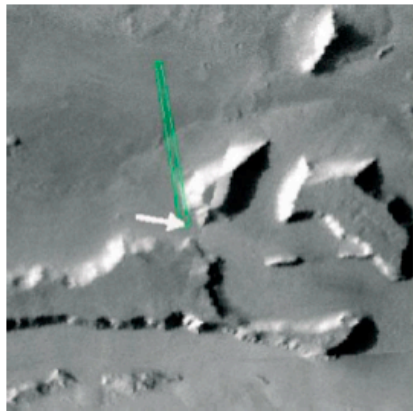
(a)

(a) Smooth surface texture may represent original apron surface



(b)

(b) Pitted surface texture may develop through ice sublimation induced collapse

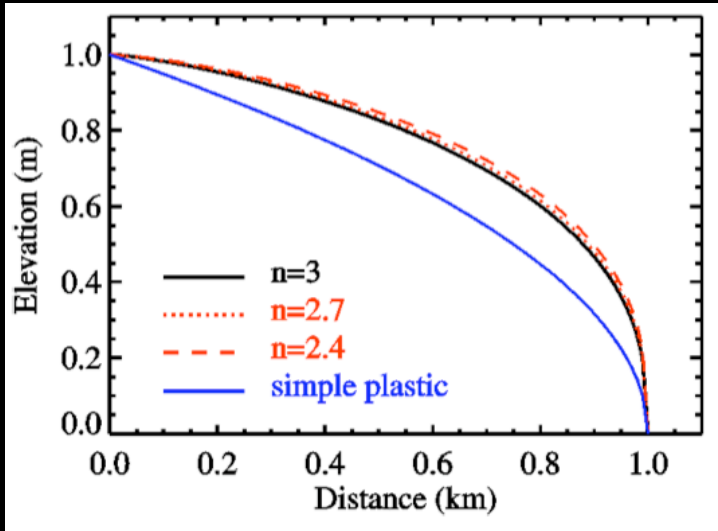


(c)

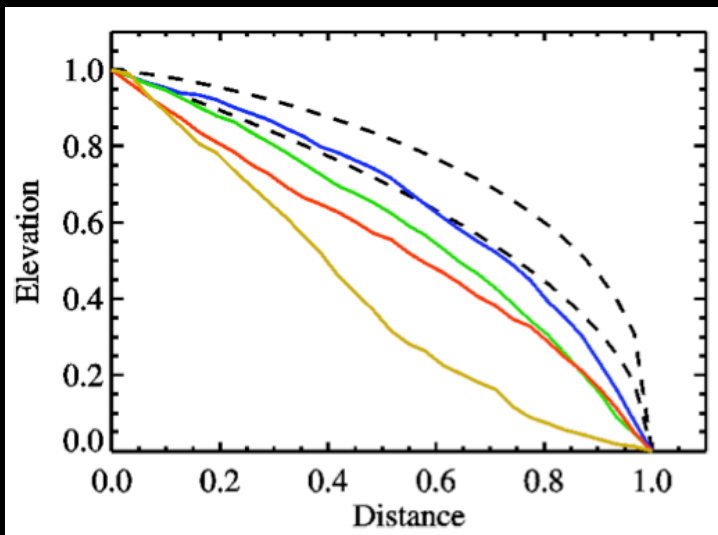
(c) Ridged texture

Debris Aprons

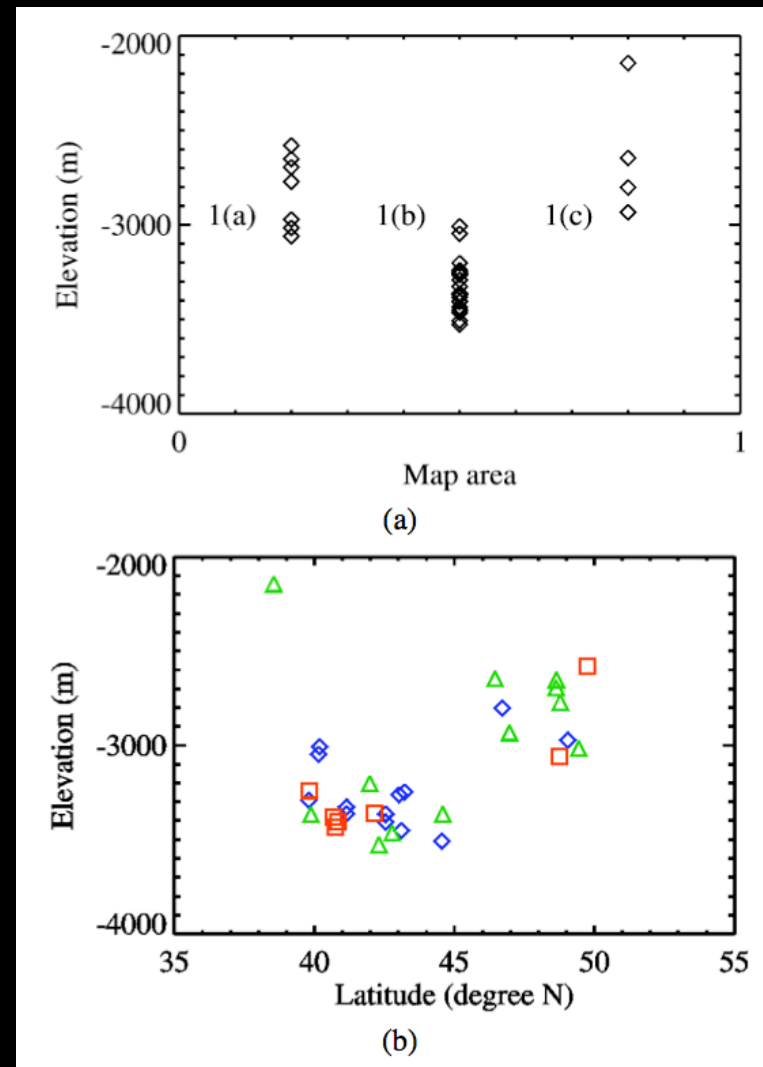
Li, Robinson, Jurdy (2005)



Above: Longitudinal profile predicted by viscous power law model when n varies within the range of 2.4 to 3.



Left: Composite profiles of three types of lobate debris aprons and Valles Marineris landslide, normalized to unit length and thickness.



Above: Relationships between apron type and (a) elevation and (b) latitude (type I blue diamond shape, type II green triangle, type III red square).

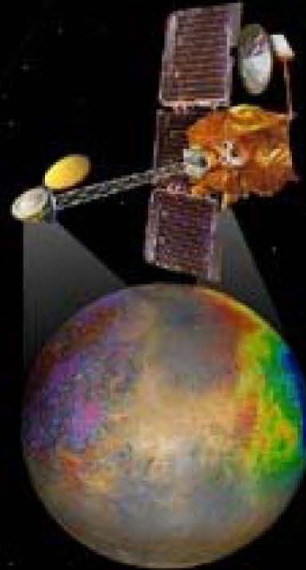


NASA's Mars Exploration Program

Mars Global Surveyor (MGS)



Mars Odyssey



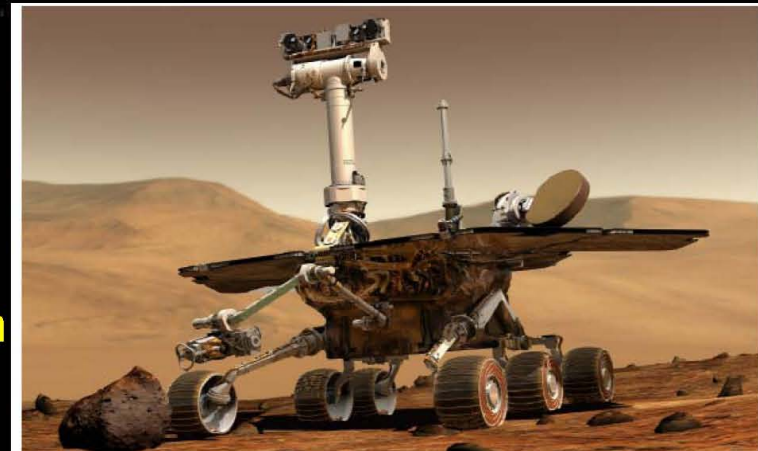
Mars Reconnaissance Orbiter



Mars Express



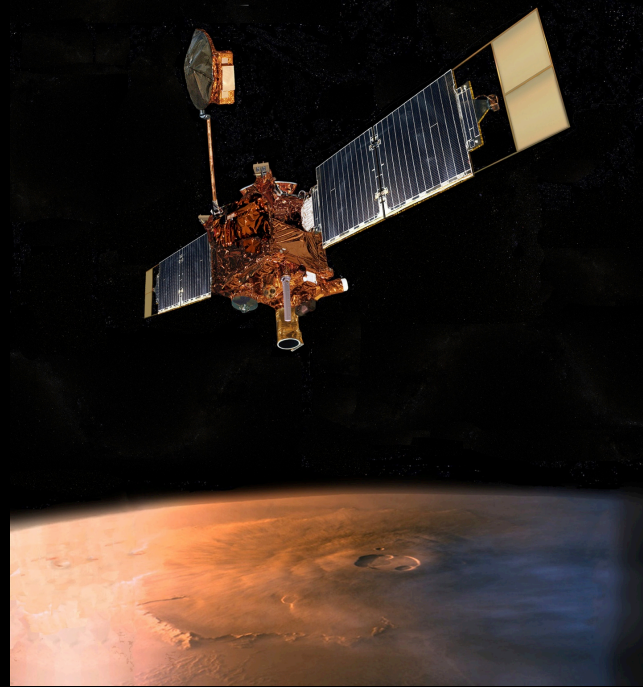
Mars Exploration Rovers (MERs)



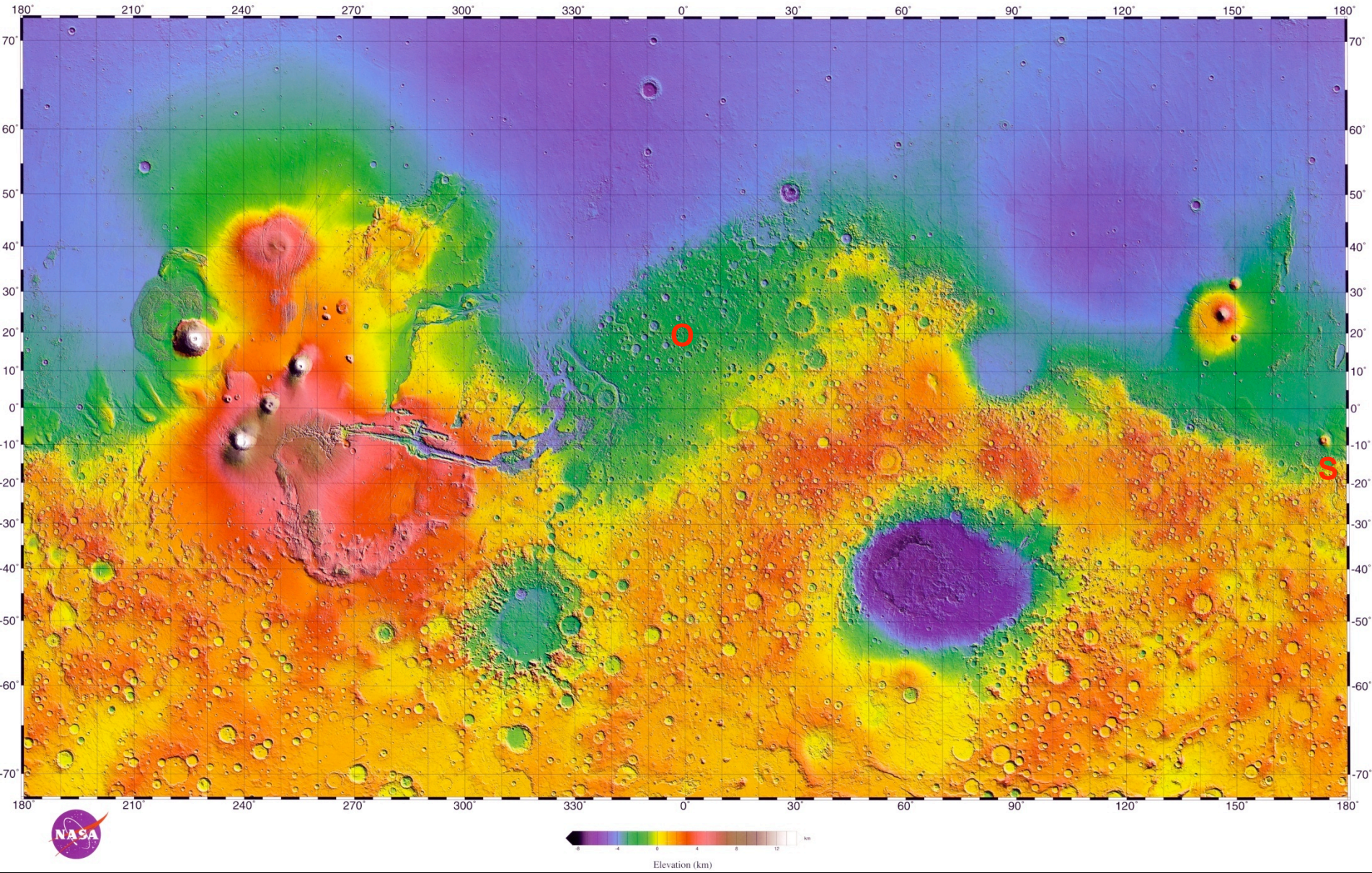
Artist's simulation of a Mars Exploration Rover at work on Mars.

Mars Global Surveyor Liftoff

November 7, 1996



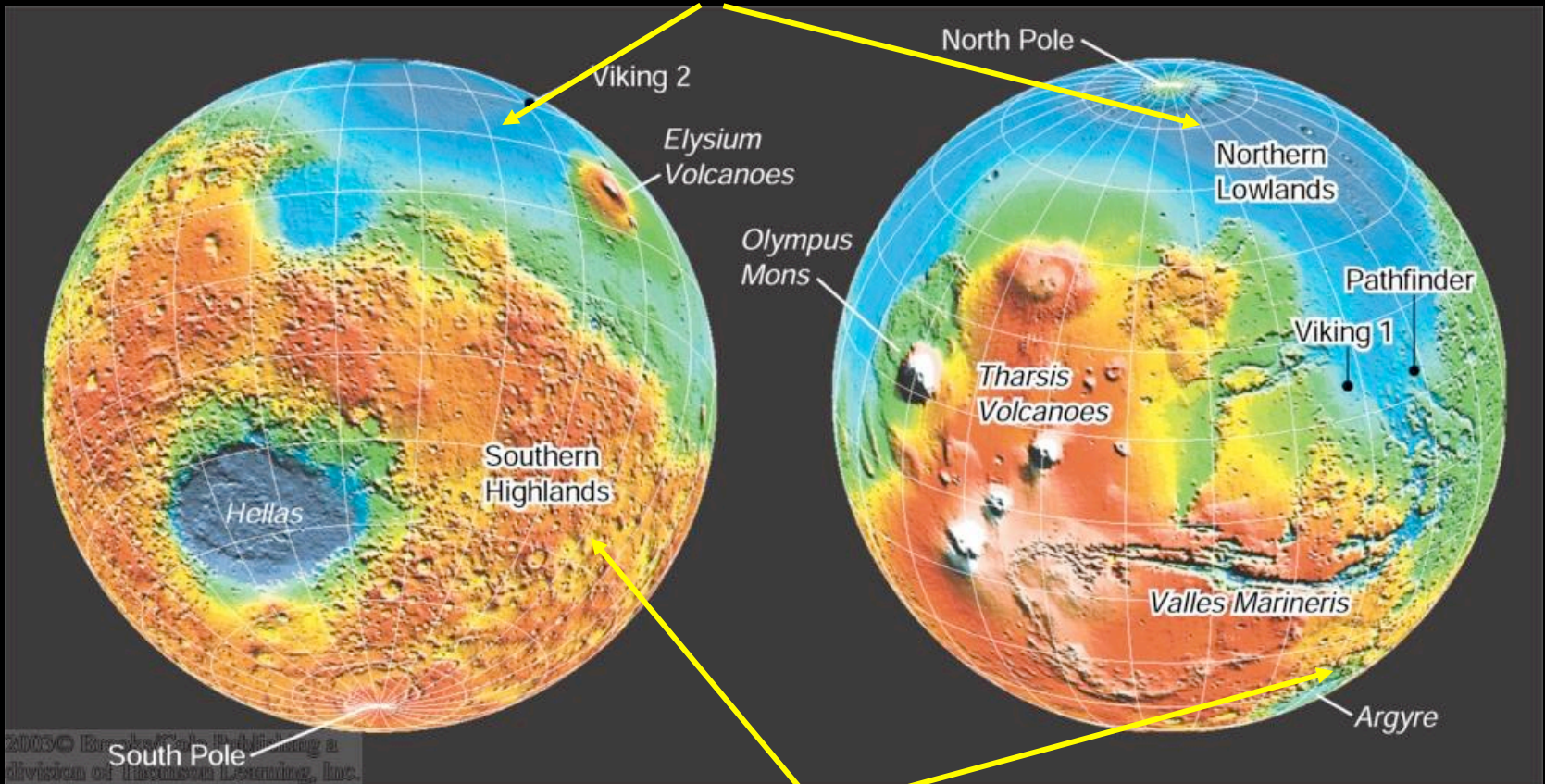
The Topography of Mars



The Geology of Mars

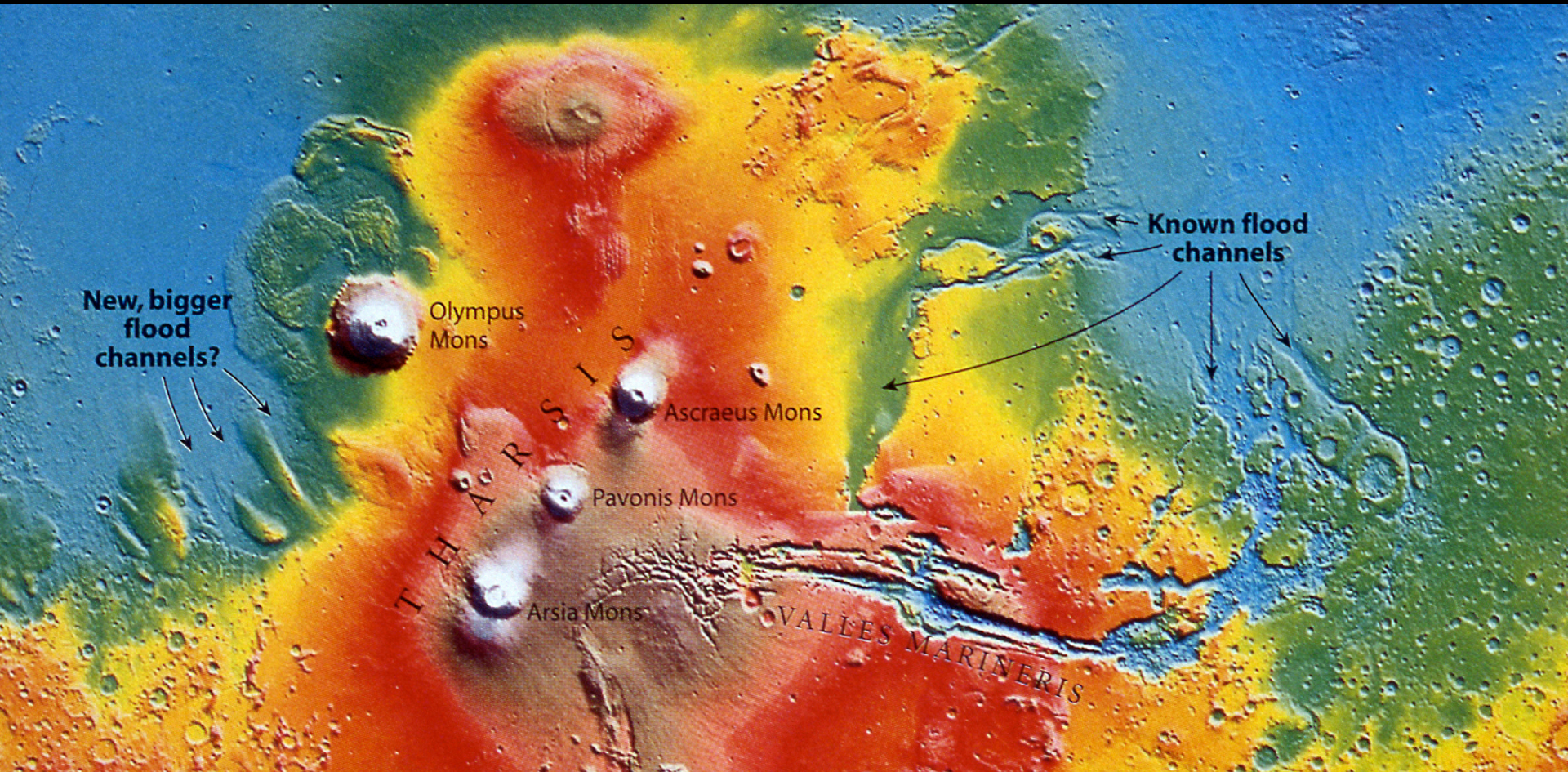
Northern Lowlands: Free of craters; probably re-surfaced a few billion years ago.

Possibly once filled with water.

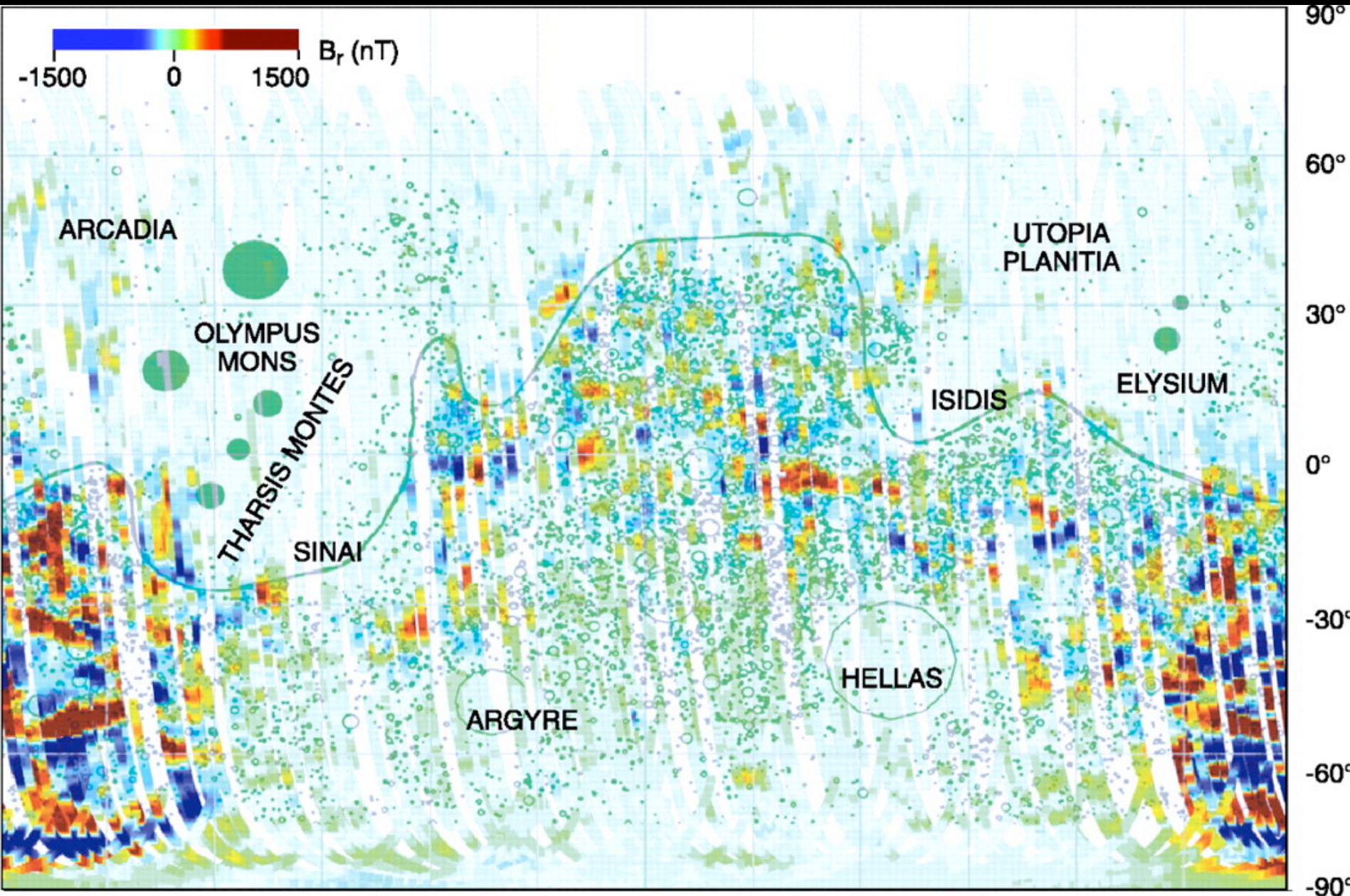


Southern Highlands: Heavily cratered; probably 2 – 3 billion years old.

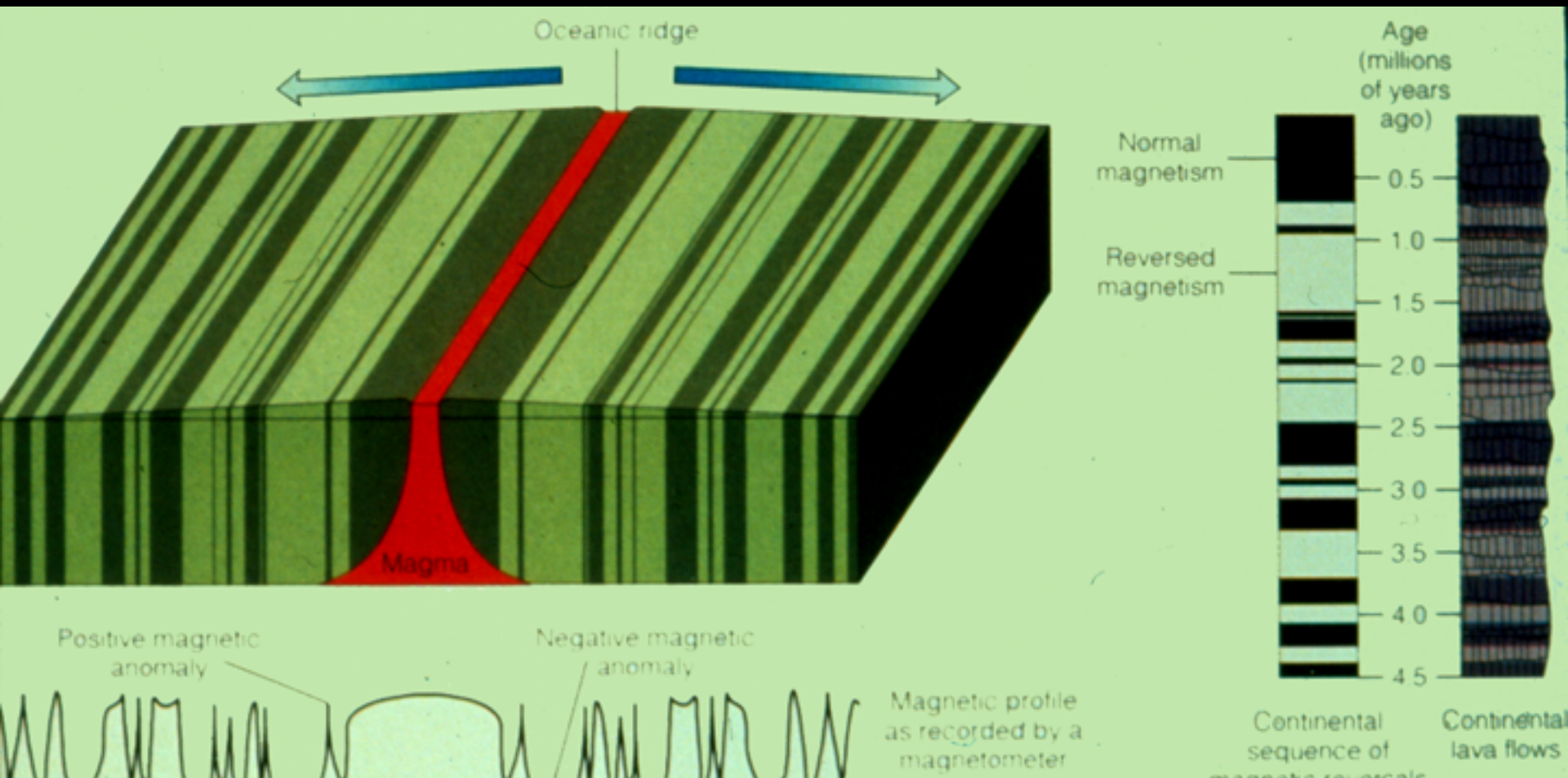
Tharsis Region Topography



Martian Magnetics



Generation of Magnetic Lineations



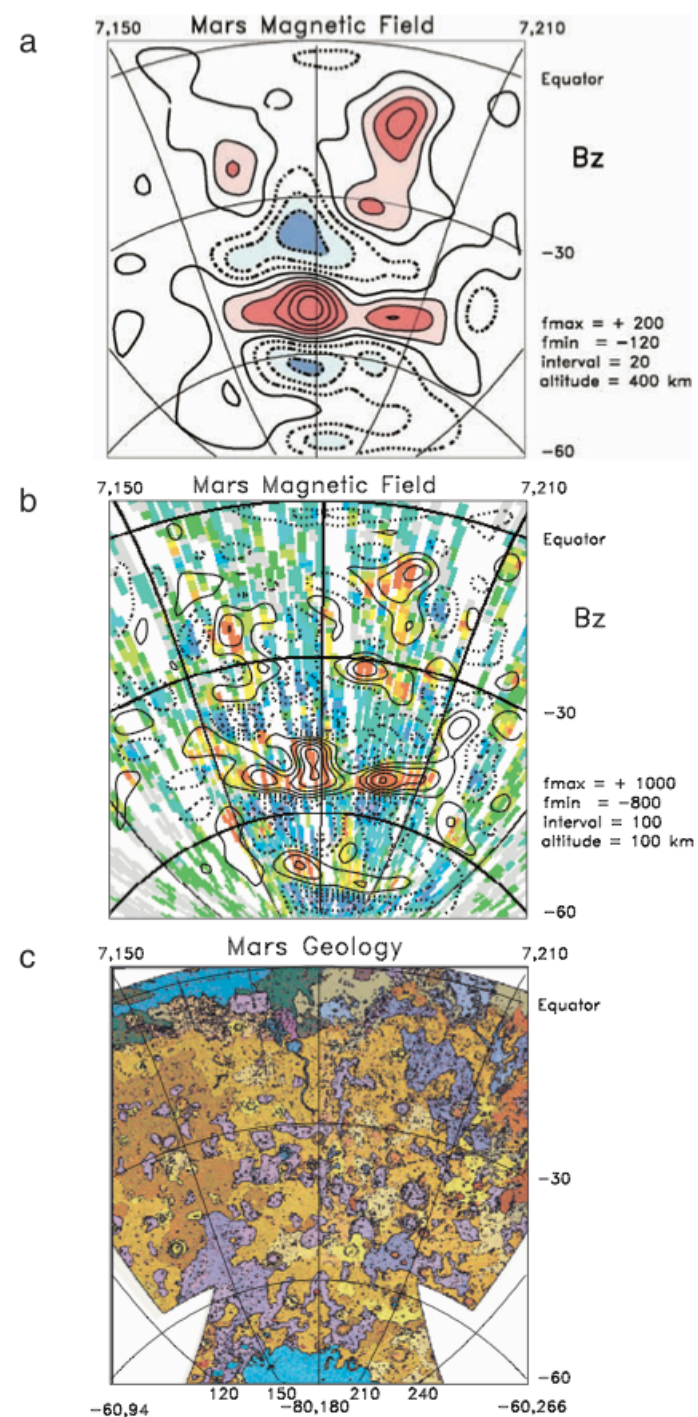
Magnetization of Mars

Figure:

(a) The vertical component of the magnetic field B_z as measured at 400 km.

(b) The vertical component of the magnetic field B_z extrapolated downward from 400 to 100 km using a Fourier transform. The result agrees very well with aerobraking data obtained at 100 km (shown in color) and fills in data gaps. Aerobraking data: **red**, strongly positive; **blue**, strongly negative.

(c) Geology of Mars' highland terrain.



Magnetization of Mars

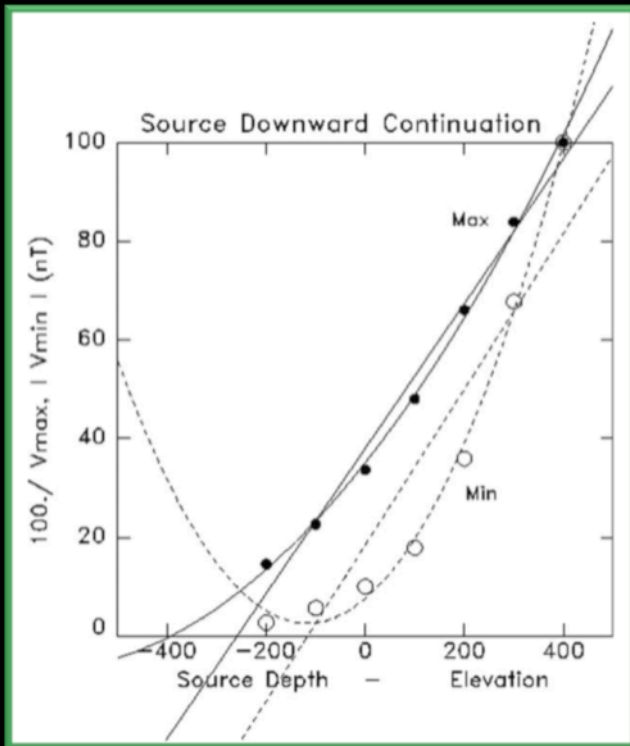


Figure: Reciprocals of maximums and minimums of sources in model shown as a function of altitude and depth of extrapolation. Linear and parabolic fits are made for maximums of the positives (solid circles) and for minimums of the negatives (open circles).

Jurdy and Stefanick (2009)

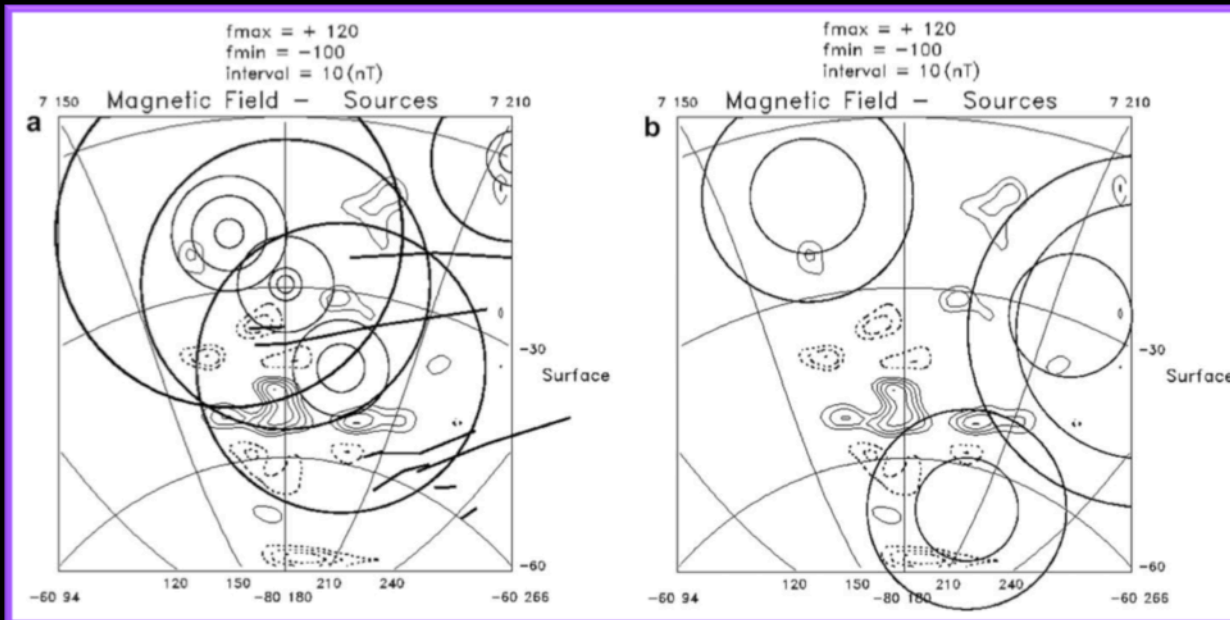
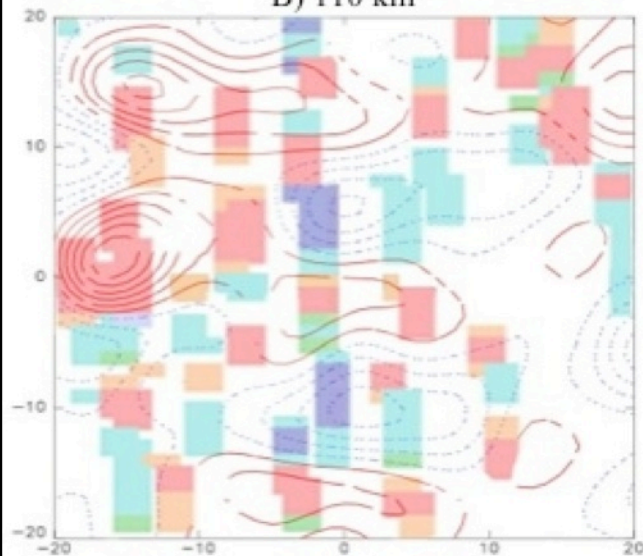


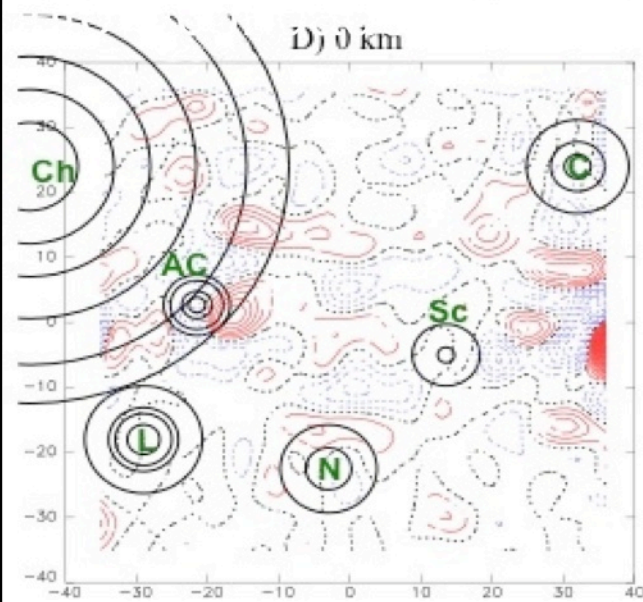
Figure: (a) Sources for magnetic field vertical component at Mars' surface. (b) Craters based on MOLA topography.

Jurdy and Stefanick (2009)

B) 110 km


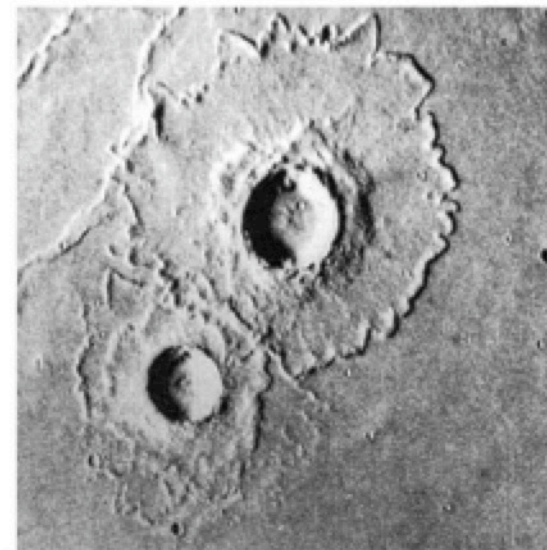
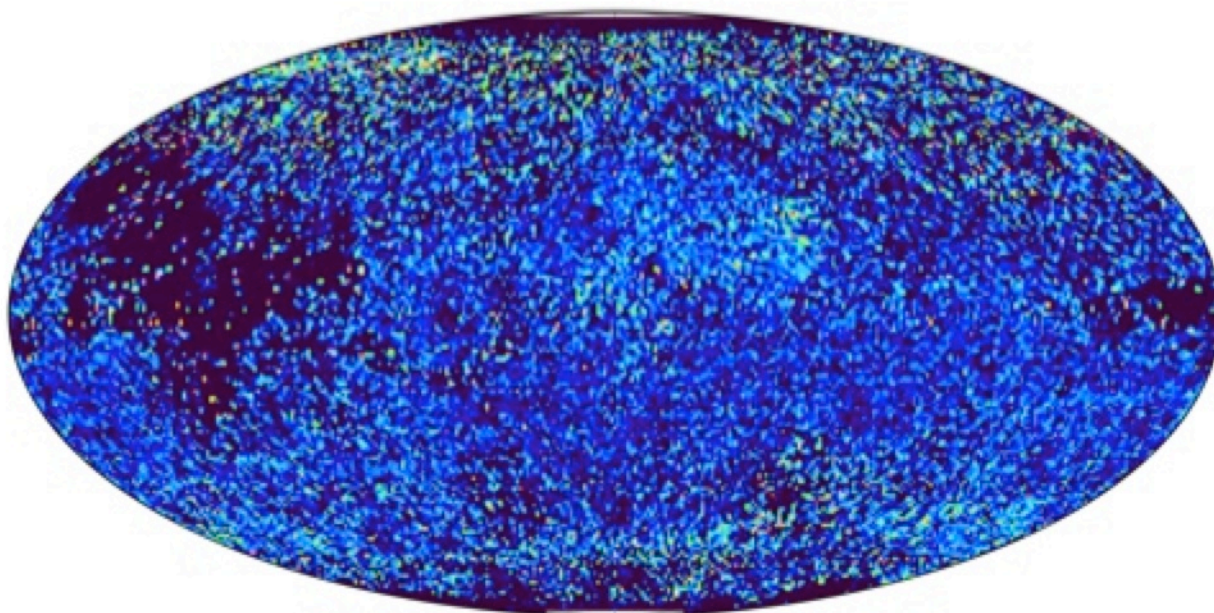
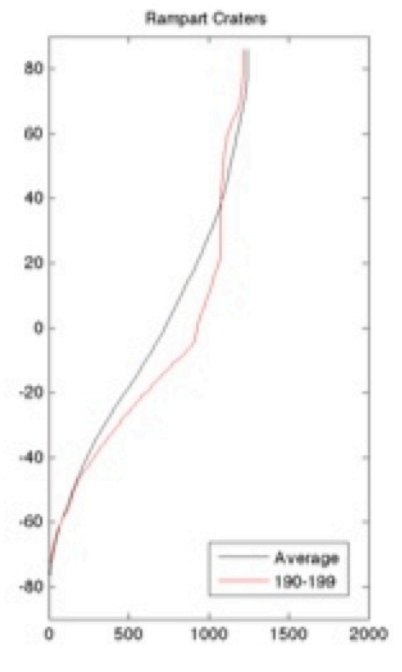
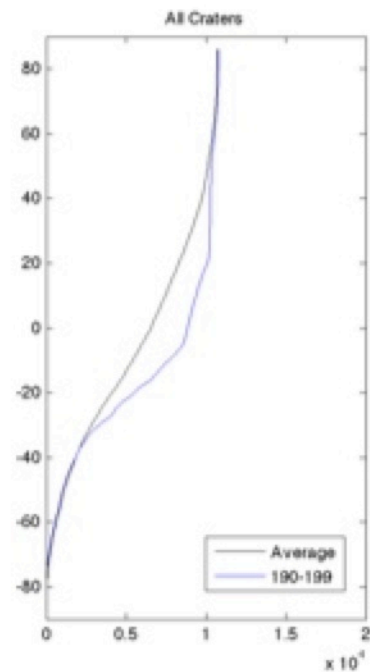


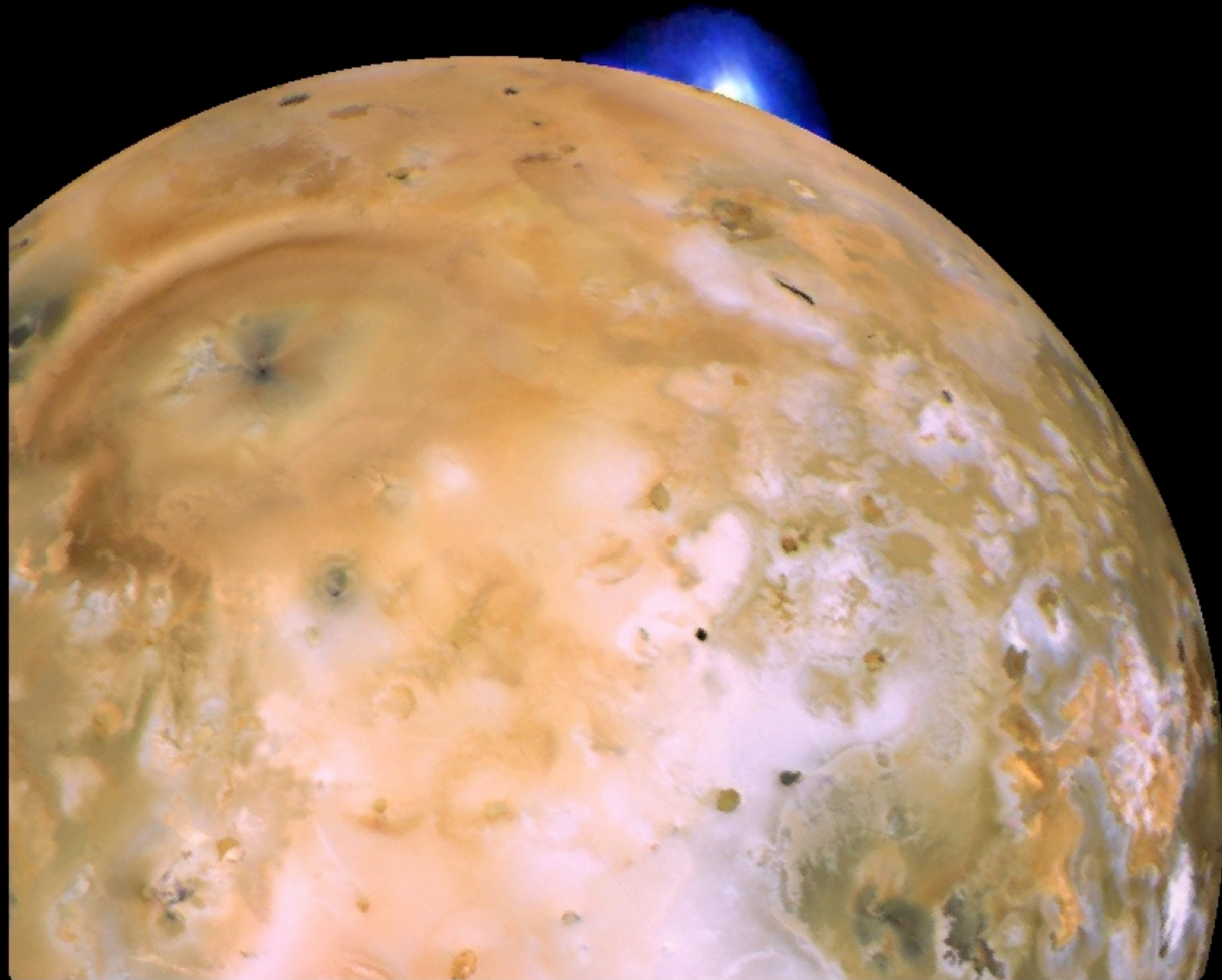
D) 0 km



Martian Rampart Craters

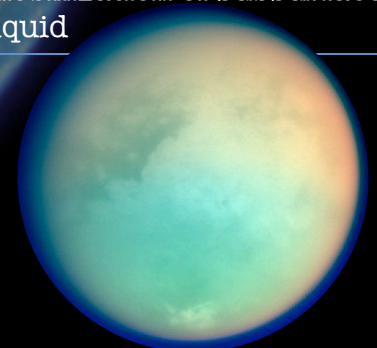
Rampart Crater Fraction

A horizontal color scale bar ranging from dark blue on the left to dark red on the right, with intermediate colors of cyan, green, yellow, and orange. The scale is labeled 'Rampart Crater Fraction' above it.



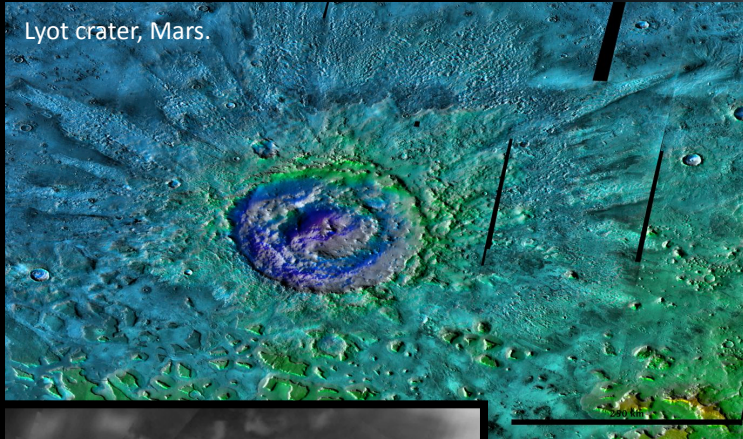
Palaeoflooding on Mars, Earth, and Titan

Parameter	Mars	Earth	Titan
Surface gravity (m/s ²)	3.71	9.81	1.35
Surface temperature (K)	210	287	94
Surface pressure (bar)	0.007	1.01	1.5
Atmospheric composition	95% CO ₂ , 2.7% N ₂ , 1.6% Ar	79% N ₂ , 20% O ₂	95% N ₂ , 5% CH ₄
Fluvial liquid, density (kg/m ³)	H ₂ O, 1000	H ₂ O, 1000	CH ₄ /N ₂ , 450
Liquid viscosity (Pa s)	1 × 10 ⁻³	1 × 10 ⁻³	2 × 10 ⁻⁴
Flood-generating mechanisms	Basin overflow, precipitation, volcanism, impact-induced precipitation and groundwater release	Glaciation, volcanism, basin overflow, precipitation	Possible causes: cryovolcanism, basin overflow, precipitation, impact-induced precipitation and mobilization of subsurface liquid

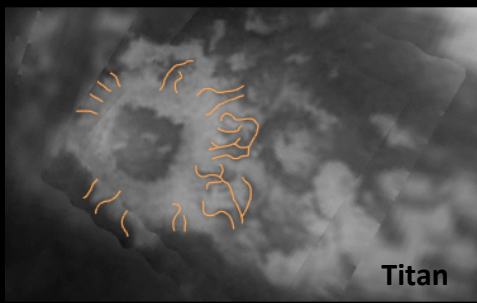
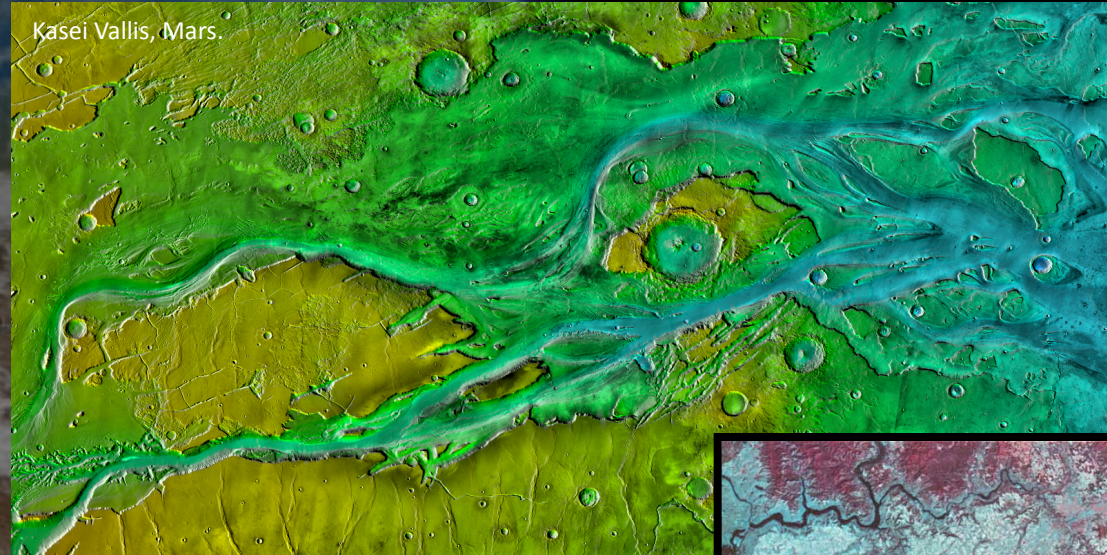


Palaeoflooding on Mars, Earth, and Titan

Lyot crater, Mars.

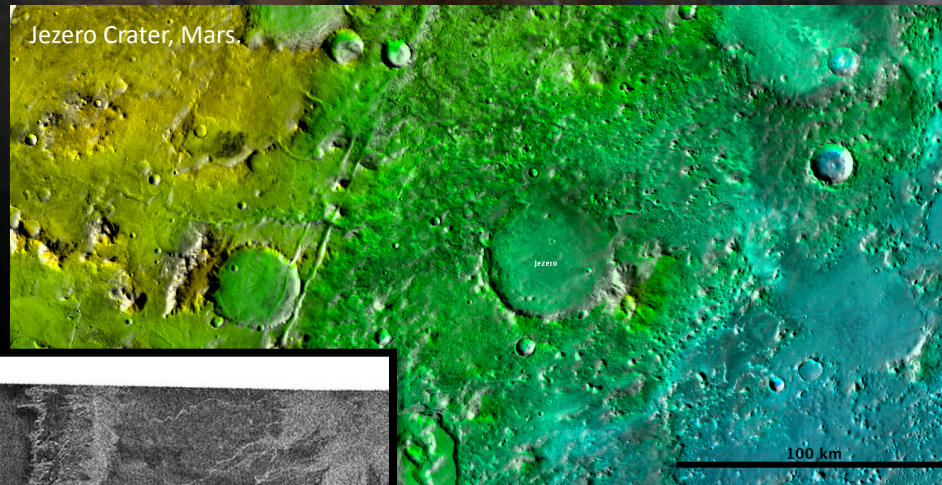


Kasei Vallis, Mars.



Titan

Radial network of channels surrounding Selk crater, Titan.

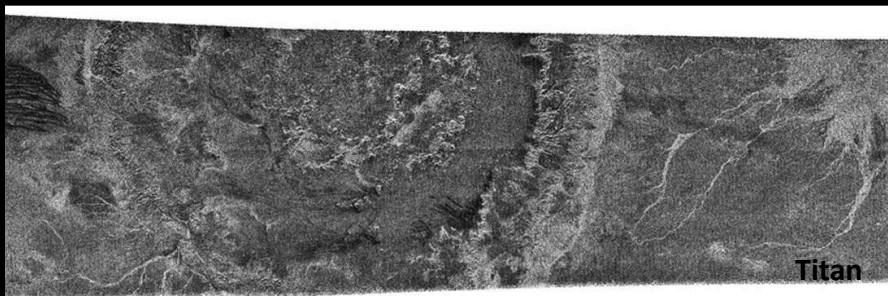


Jezero Crater, Mars.



Earth

Channeled Scabland region, Earth. The dark braided pattern depicts the channelways of the Great Spokane Flood.



Titan

Channels flowing into and out of Menrva crater, Titan.

Eberswalde Crater

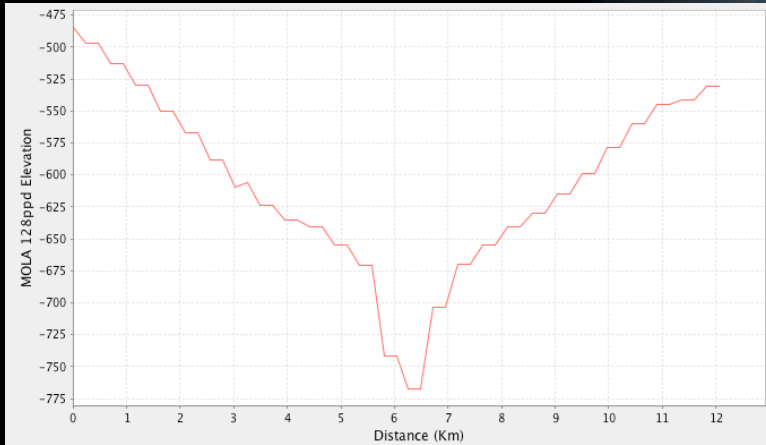
Located at 24.3°S, 33.5°W

Located 50 km north of the 150 km diameter crater Holden

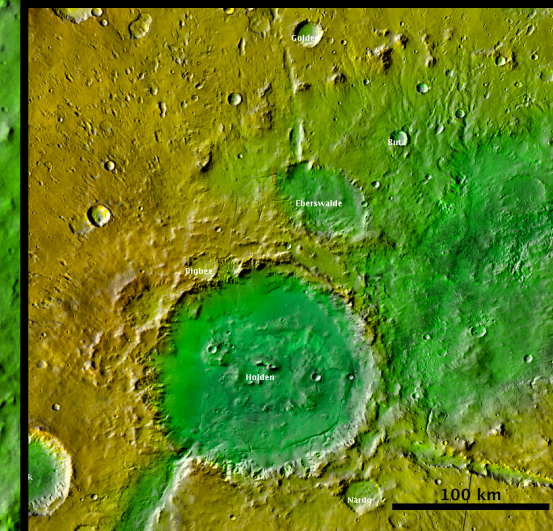
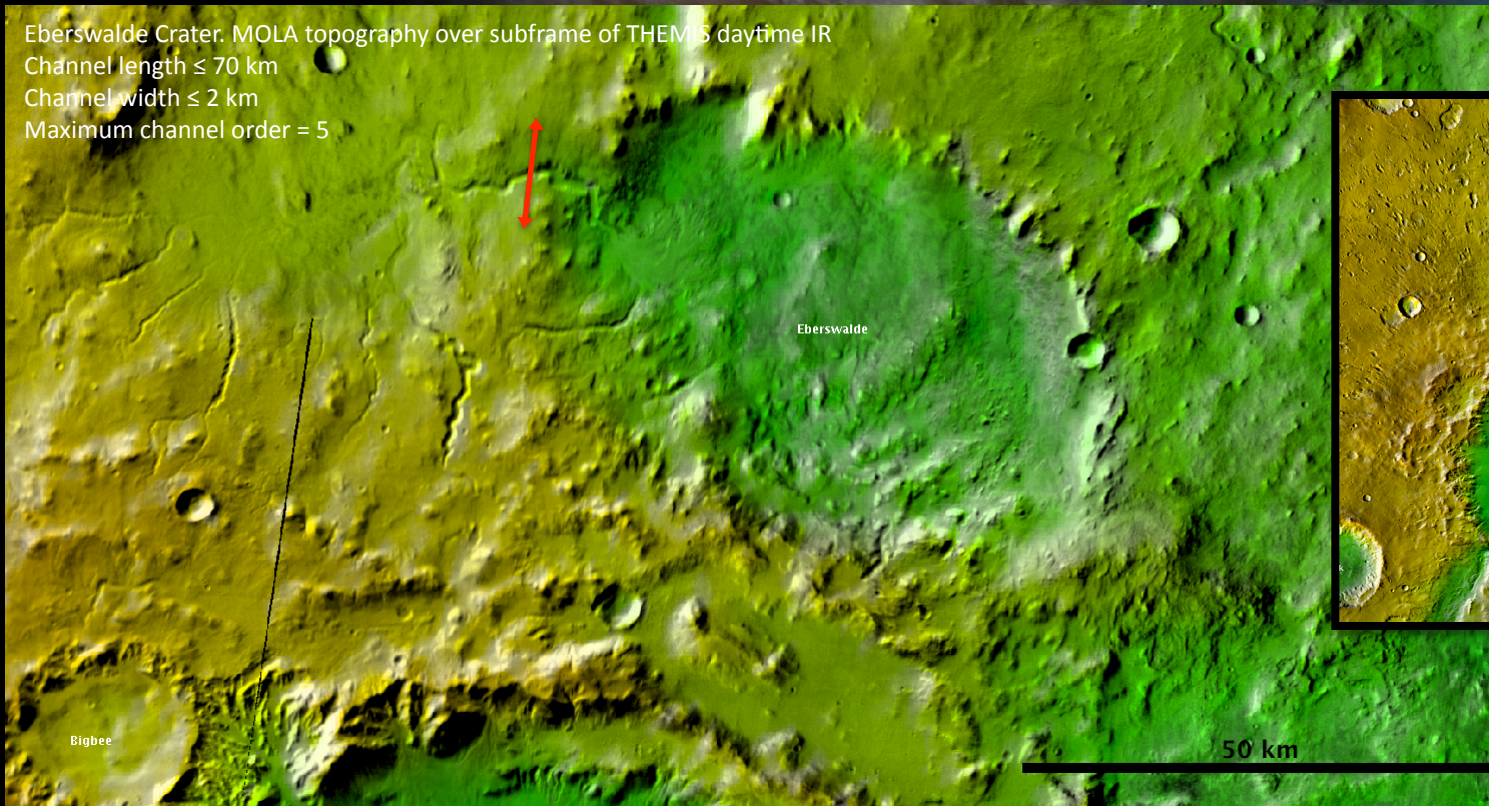
Evidence of an ancient network of multi-order tributaries that feed a fan deposit in the northwest margin of the crater. This fan is usually interpreted as a delta formed in a standing body of water over a period of a few years to > 100,000 years.

Stratigraphic relationship between Holden crater ejecta and Eberswalde's fluvial valleys and depositional fans shows that Holden formed before fluvial activity in Eberswalde.

Suggested that the Holden impact event triggered flooding by local heating of pre-existing ground ice possibly in combination with climatic triggers.



Eberswalde Crater. MOLA topography over subframe of THEMIS daytime IR
Channel length ≤ 70 km
Channel width ≤ 2 km
Maximum channel order = 5

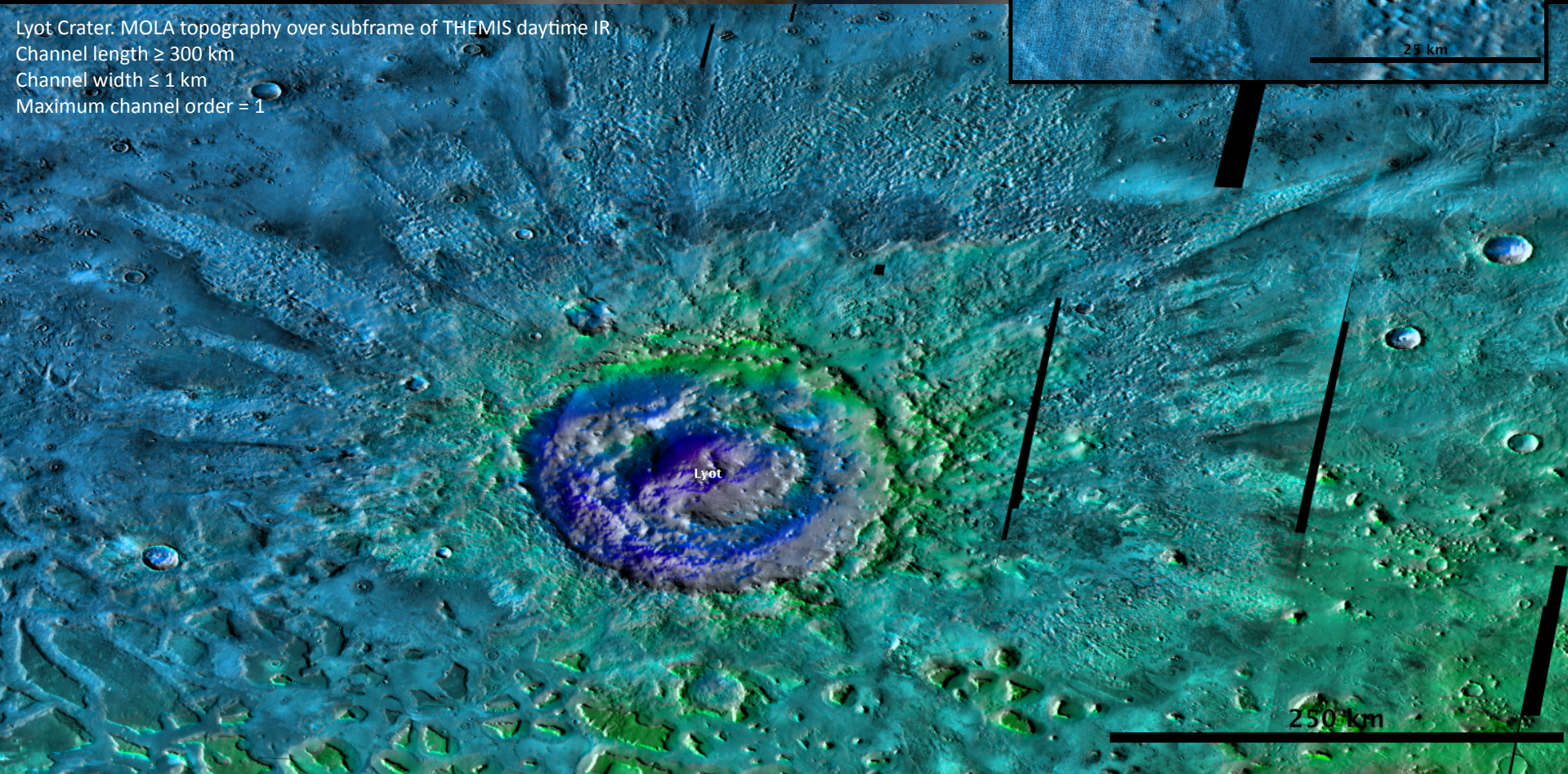
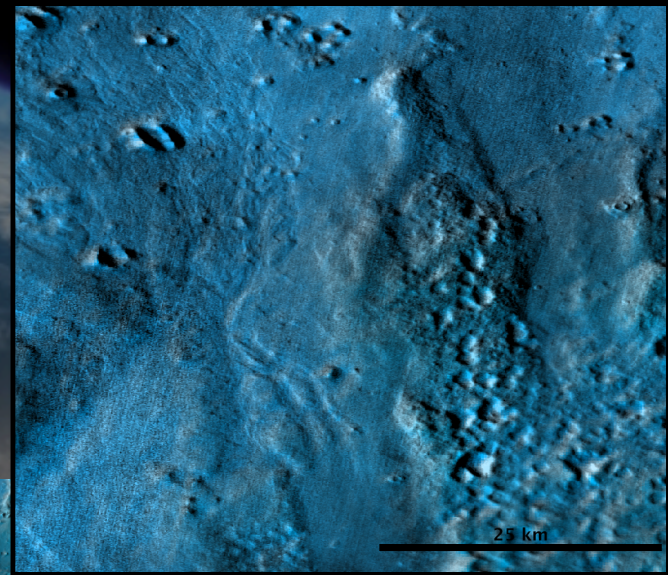


Lyot Crater

Located at 50.7°N, 29.2°E

To the north, west, and east of Lyot is an extensive channelized scabland region, including braided reaches and large areas of scour.

Channels cover about 300,000 km² and are attributed to carving by sediment-laden water from the target substrate and/or nearby terrain via either mobilization of shallow groundwater by seismic energy from the impact event or dewatering of the ejecta.



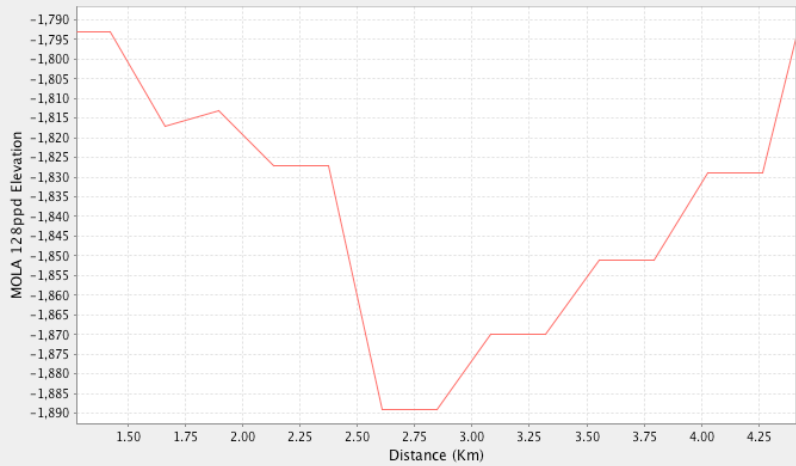
Lyot Crater. MOLA topography over subframe of THEMIS daytime IR.
Channel length ≥ 300 km
Channel width ≤ 1 km
Maximum channel order = 1

Jezero Crater

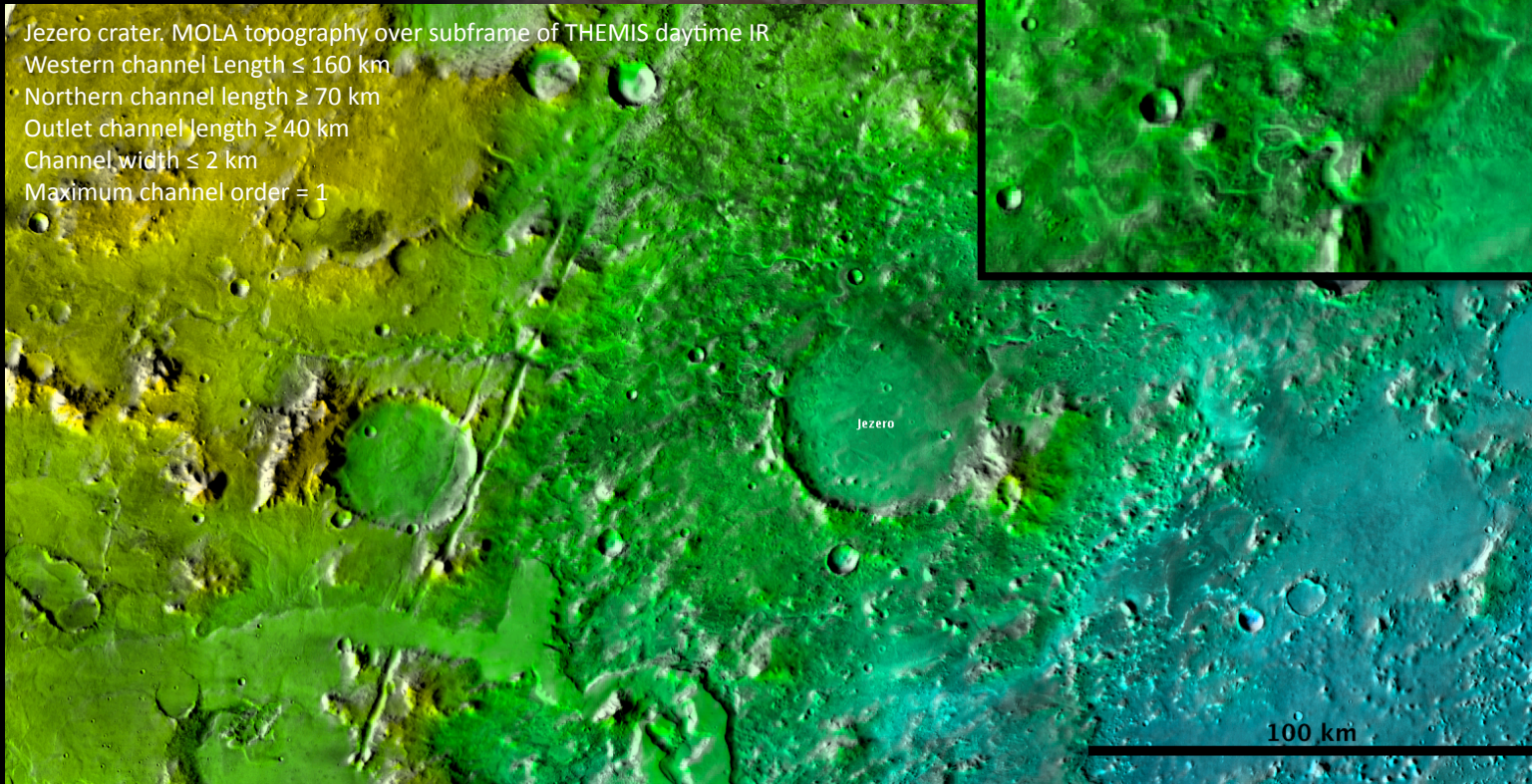
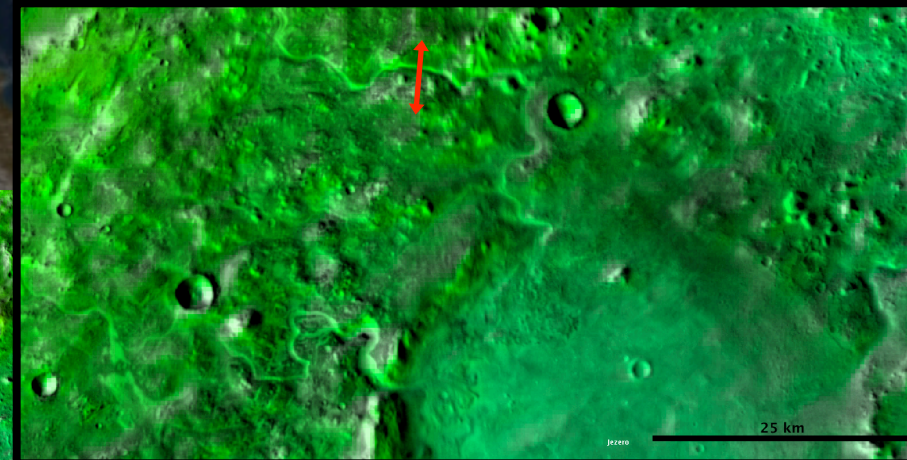
Two valleys enter the crater from the west and north, depositing sediments at their mouth.

Influx of water from these valleys filled the crater until the eastern rim was overtopped and breached. Water then flowed from an exit valley into the adjacent lowlands.

Jezero could have been filled in as little as 11 Earth years. Such a short time is only possible if there was a continuous source of supply such as impact-driven precipitation.



Jezero crater. MOLA topography over subframe of THEMIS daytime IR
Western channel Length ≤ 160 km
Northern channel length ≥ 70 km
Outlet channel length ≥ 40 km
Channel width ≤ 2 km
Maximum channel order = 1



Conclusions

Mars had a magnetic field early in its history.

Martian crust either very strongly magnetized or extending to great depth. Perhaps both.

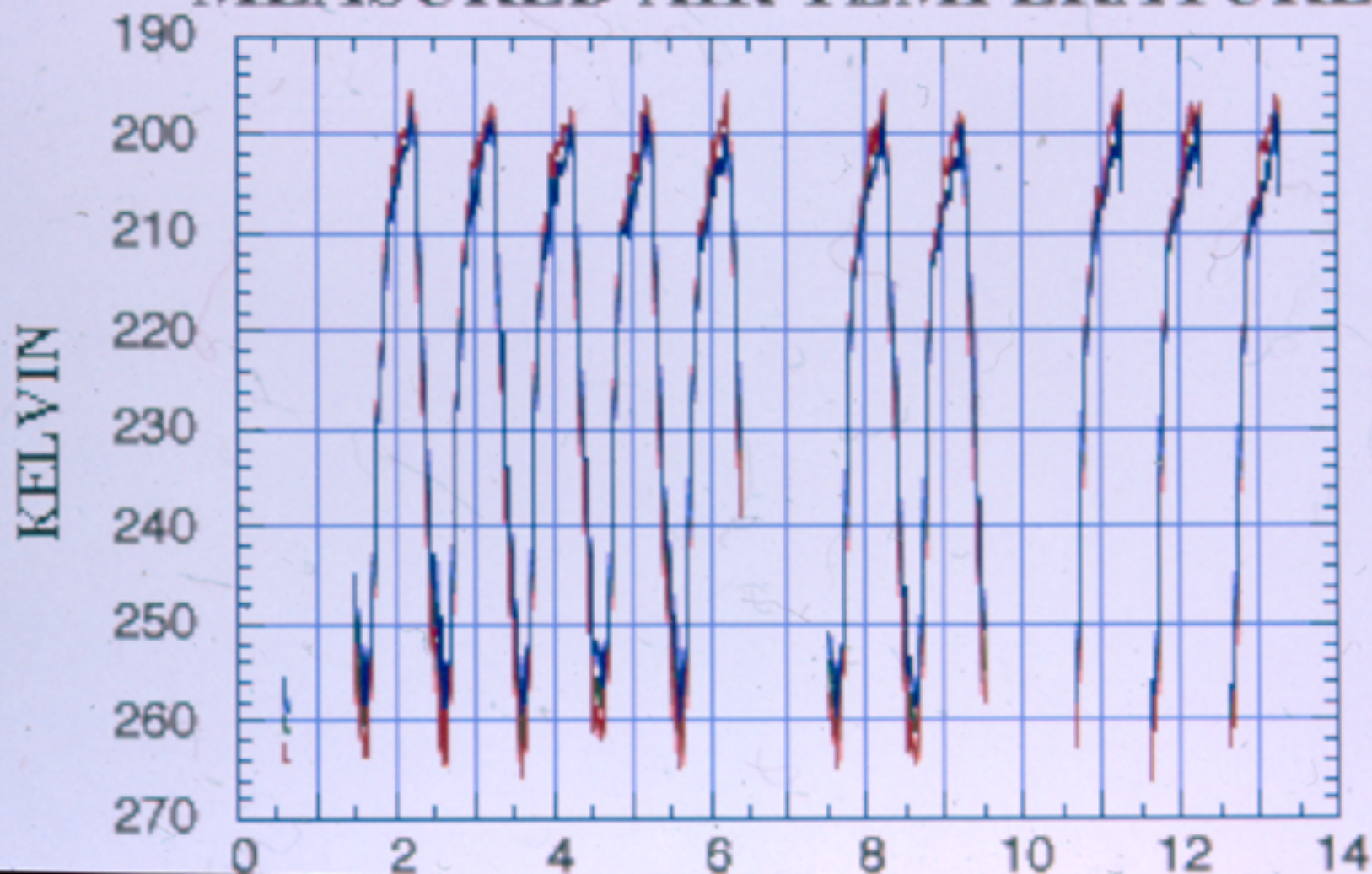
TPW may have occurred on Mars.

Io, the most volcanically active body, promising candidate

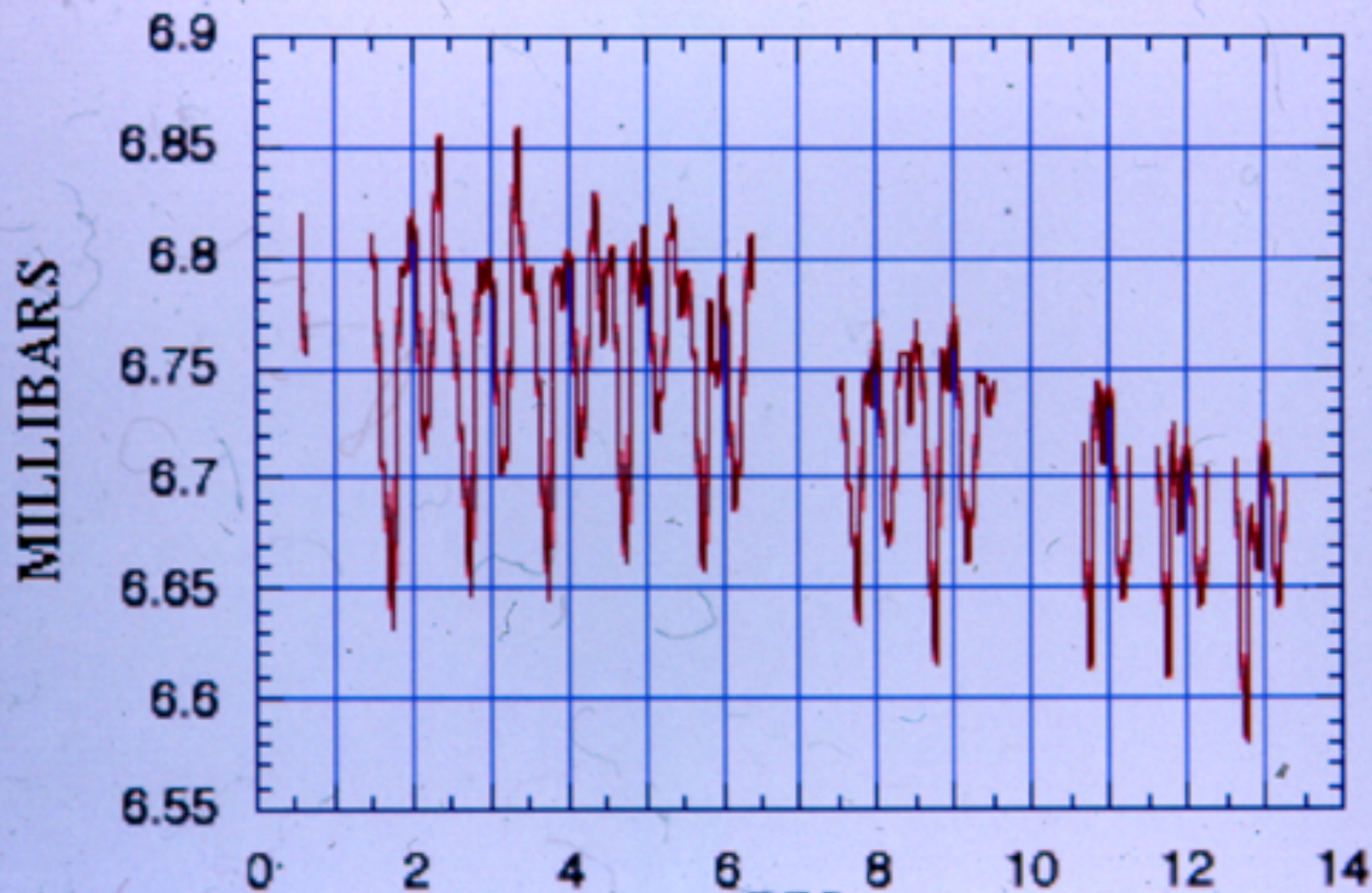
Sunset on Mars (Spirit)

— MIDDLE — BOTTOM — TOP

MARS PATHFINDER MEASURED AIR TEMPERATURES



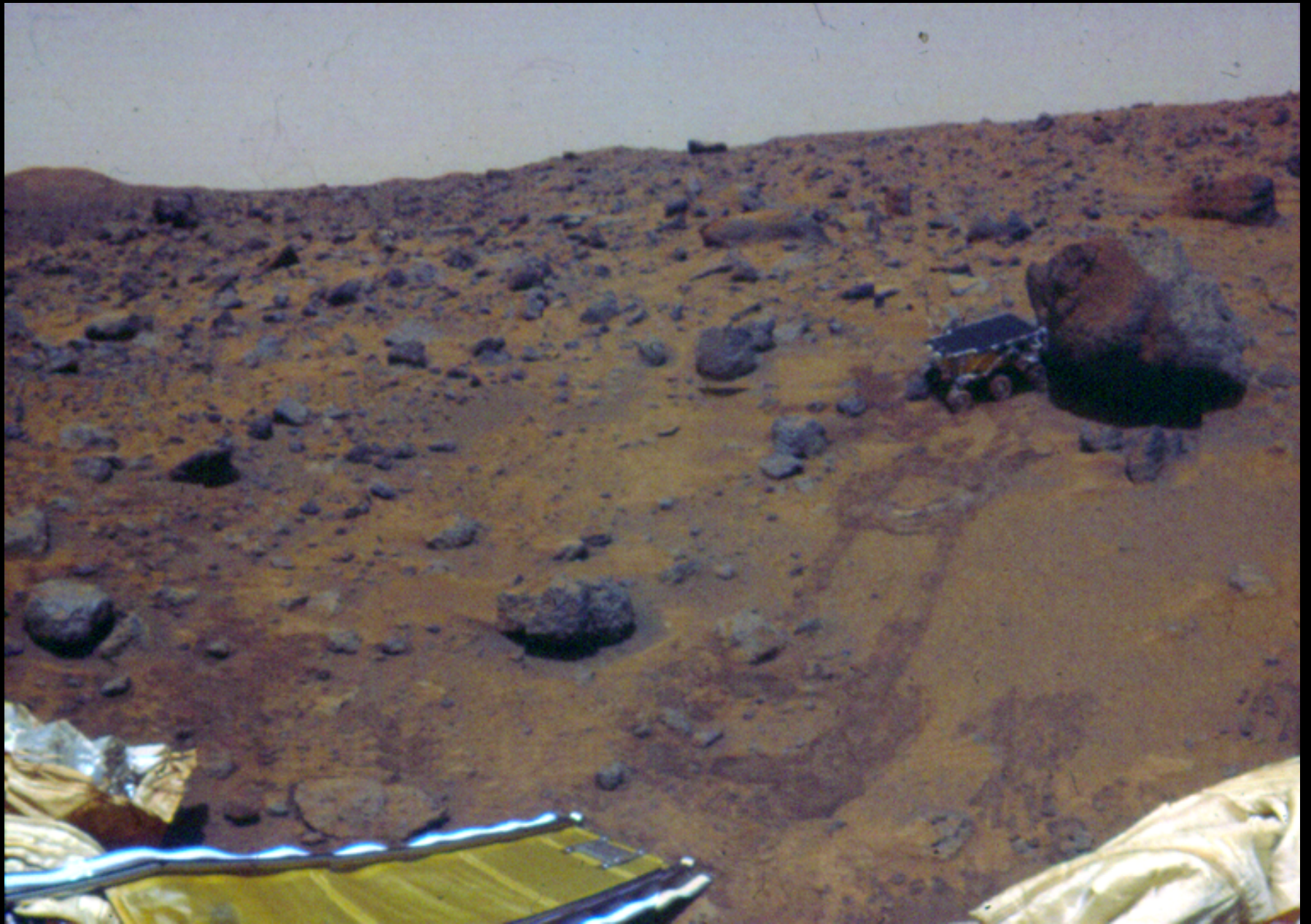
MARS PATHFINDER MEASURED SURFACE PRESSURE



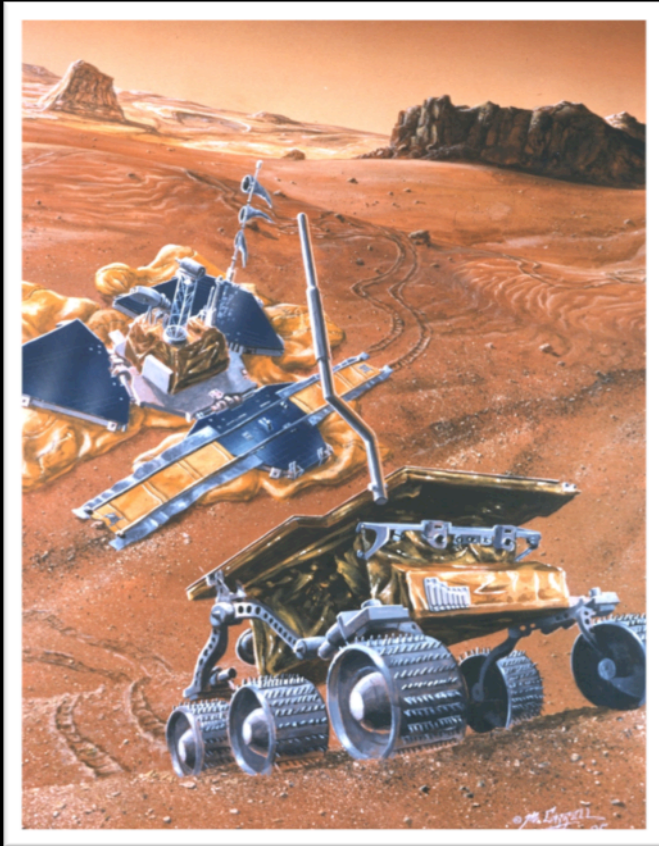
Sojourner



Sojourner at Yogi

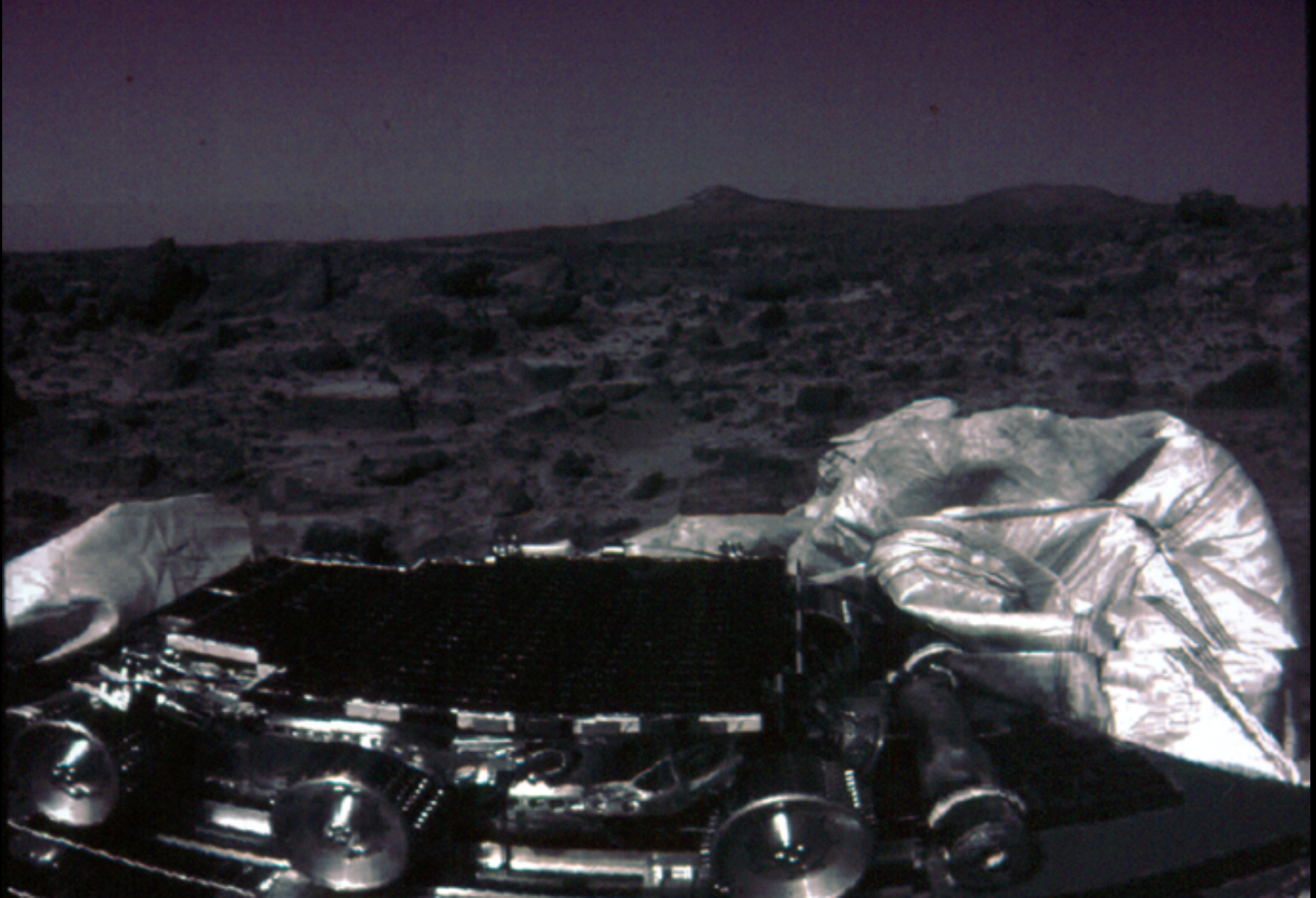


Pathfinder results

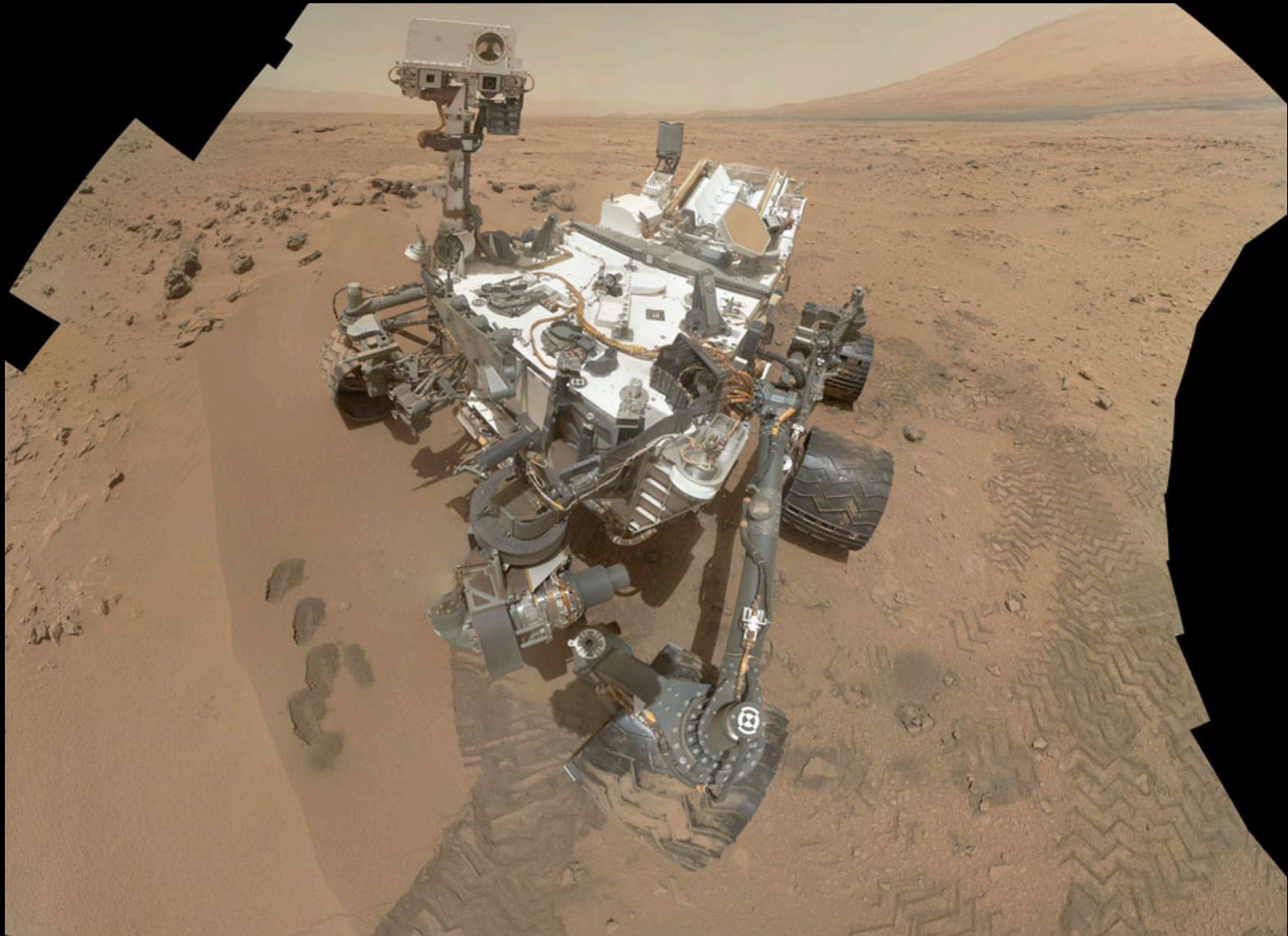


- Most rocks analyzed are basalt
- One is slightly more rich in silica
 - Could indicate tectonic activity?
 - Or could be a weathering effect

Pathfinder/Sojourner

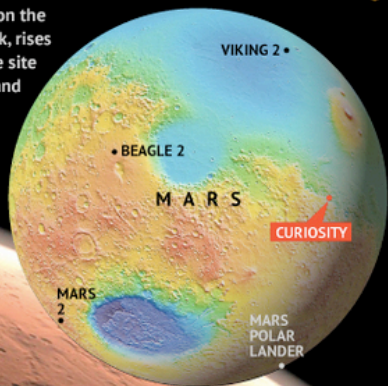


Curiosity

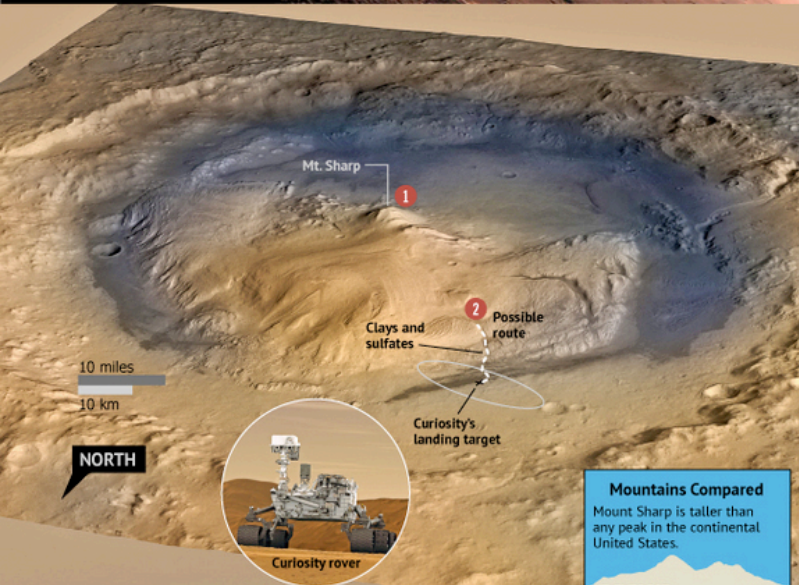
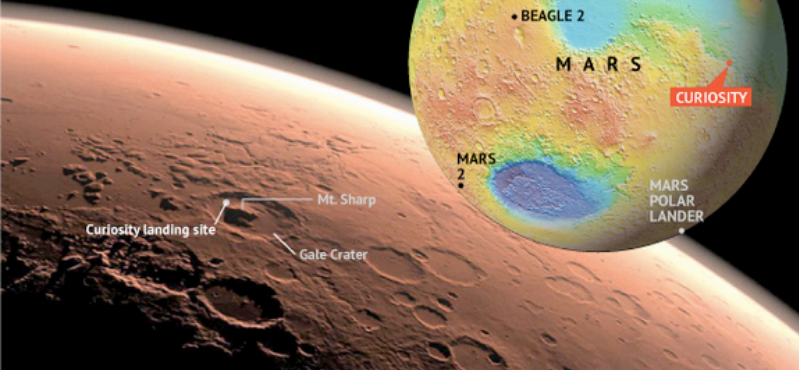


Mountain-Climbing Rover Aims for Gale Crater Landing

Curiosity's landing target is Gale Crater, located on the equator of Mars. Mount Sharp, Gale's central peak, rises 3 miles (5 kilometers) above the crater floor. The site is poised between Mars' flat northern lowlands and the heavily cratered southern hemisphere.



Curiosity Landing Site



- 1 Curiosity's primary target is the layered mound of debris making up **Mount Sharp**. Scientists expect the mound to yield information on a billion years of Martian geological and climate history.
- 2 After landing somewhere in the target ellipse on the floor of Gale Crater, the nuclear-powered Curiosity rover will roll up the flank of Mount Sharp, investigating **clays and sulfates**, minerals that form in the presence of water.



INSTRUMENTS

Leaving No Stone Unturned

Curiosity's instrument suite is designed to examine rocks, soil and atmosphere for clues to past and present habitable environments. The instruments do that by measuring chemical and mineralogical composition in various complementary ways.

WEATHER STATION will measure environmental variables and issue daily reports, providing the first ever continuous record of Martian meteorology. Apart from its inherent interest, the weather report will guide rover operations.

ACTIVE NEUTRON SPECTROMETER will search for water in rocks and soil underneath the rover.

RADIATION SENSOR will monitor solar and cosmic radiation.

COLOR CAMERAS can image landscapes and rock and soil textures in high-definition resolution. Those textures help scientists to reconstruct the processes that formed the rock or soil, perhaps including the action of liquid water. One of the cameras is mounted on the bottom of the rover, looking downward, and will create a movie of the descent and landing.

CHEMIN INSTRUMENT beams x-rays through fine powders to create a diffraction pattern that definitively identifies minerals of all types. Spectrometers on previous landers were limited in scope to, for example, iron-bearing minerals.

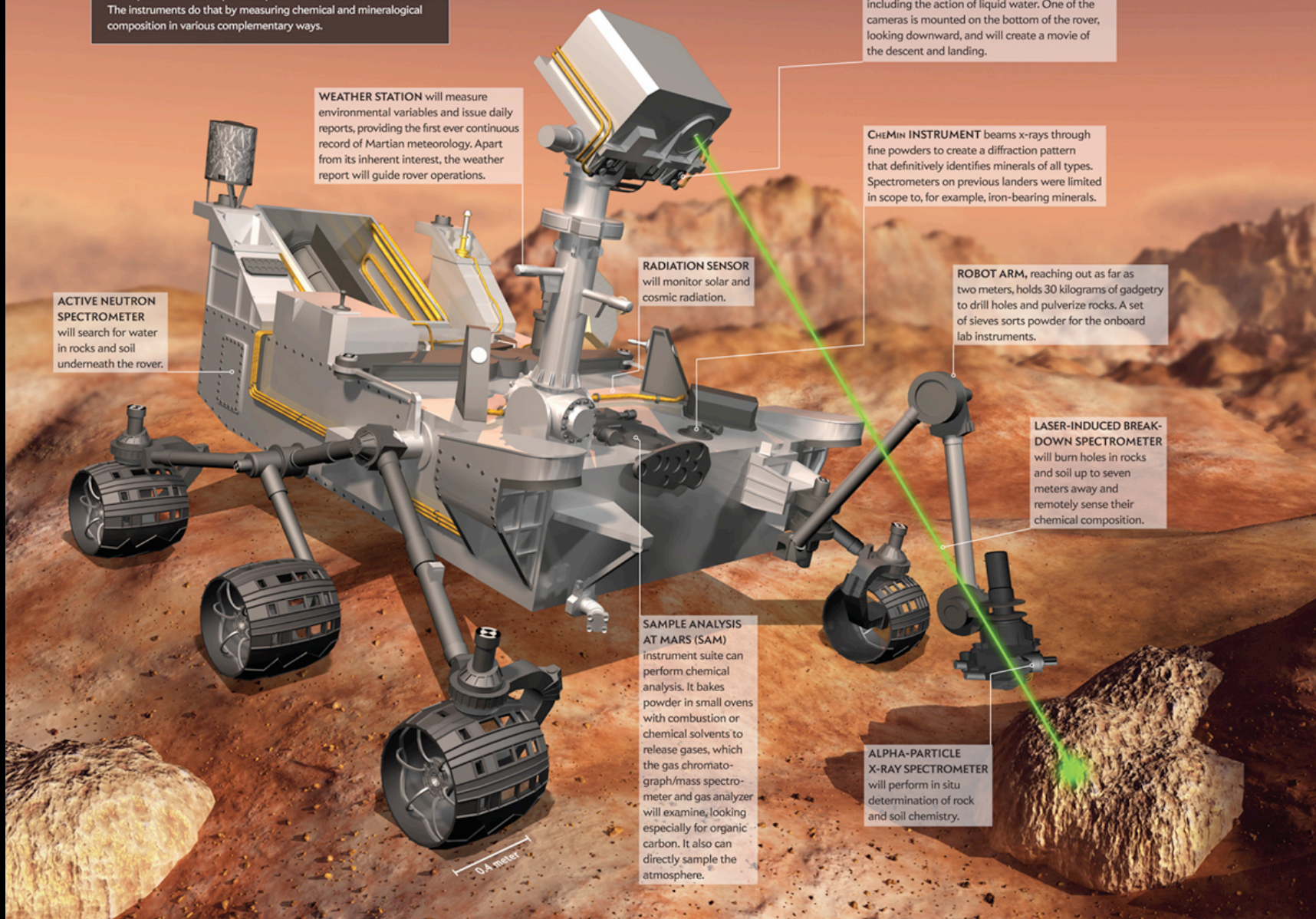
ROBOT ARM, reaching out as far as two meters, holds 30 kilograms of gadgetry to drill holes and pulverize rocks. A set of sieves sorts powder for the onboard lab instruments.

LASER-INDUCED BREAK-DOWN SPECTROMETER will burn holes in rocks and soil up to seven meters away and remotely sense their chemical composition.

SAMPLE ANALYSIS AT MARS (SAM) instrument suite can perform chemical analysis. It bakes powder in small ovens with combustion or chemical solvents to release gases, which the gas chromatograph/mass spectrometer and gas analyzer will examine, looking especially for organic carbon. It also can directly sample the atmosphere.

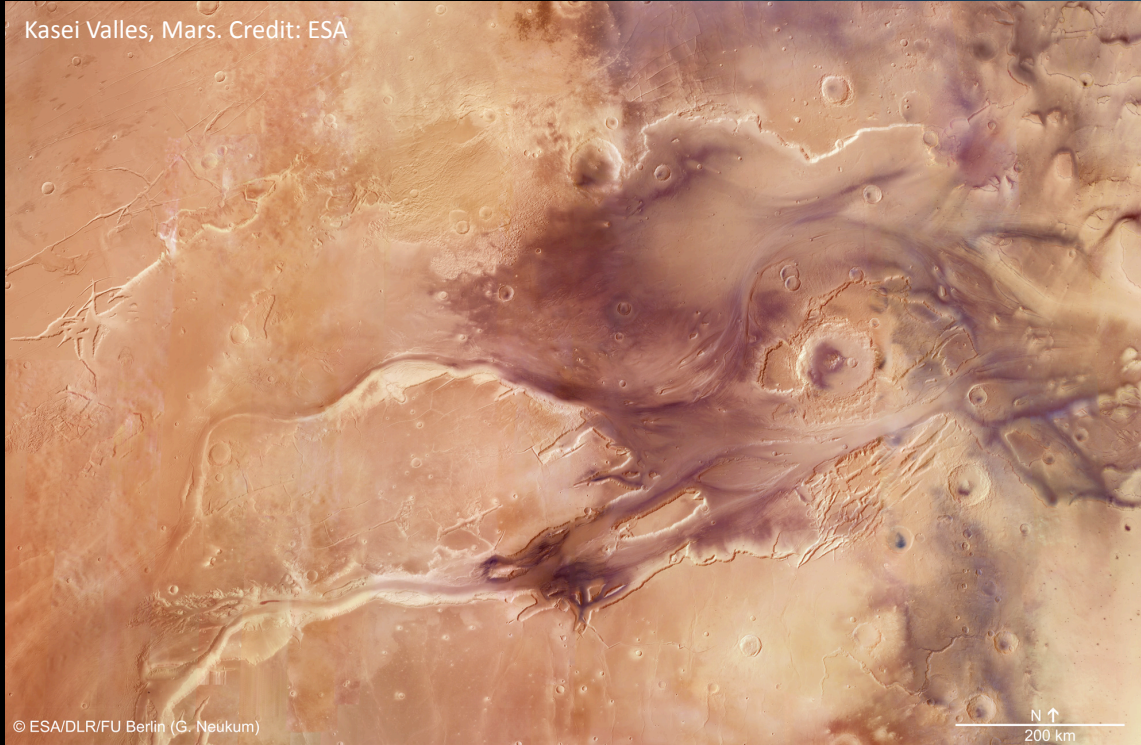
ALPHA-PARTICLE X-RAY SPECTROMETER will perform in situ determination of rock and soil chemistry.

0.4 meter



Flooding on Mars

Kasei Valles, Mars. Credit: ESA

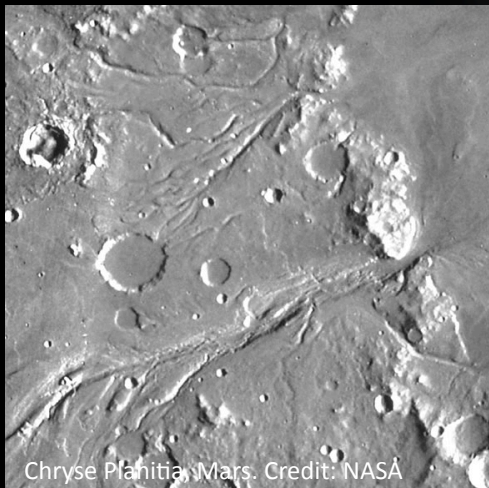


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N ↑
200 km



Channel southwest of Cerberus Fossae, Mars.
Credit: NASA/JPL/MSSS



Chryse Planitia, Mars. Credit: NASA



Dao, Niger, and Harmakhis Valles, Mars. Credit: NASA

Mariner 9 and Viking orbiter were the first missions to observe Mars' gigantic flood channels.

Mars' largest flood channels are enormous in size, with widths up to several tens of kilometers, lengths of hundreds of kilometers, and depths of over a thousand meters.

Pathfinder Landing Site (July 4, 1977)



Conclusions

- Mars may have been very Earth-like when life was beginning on Earth
 - Could life have begun on Mars?
- There is still H₂O (as ice and vapor) on Mars, and may still exist (albeit briefly, perhaps) today
 - Could there be Martians living today?